THE

Railroad Signal Dictionary

AN ILLUSTRATED VOCABULARY OF TERMS WHICH DESIGNATE AMERICAN RAILROAD SIGNALS THEIR PARTS ATTACHMENTS AND DETAILS OF CONSTRUCTION WITH DESCRIPTIONS OF METHODS OF OPERATION AND SOME ILLUSTRATIONS OF BRITISH SIGNALS AND PRACTICE

THREE THOUSAND ONE HUNDRED TWENTY-SEVEN ILLUSTRATIONS.

FIRST EDITION

COMPILED FOR

THE RAILWAY SIGNAL ASSOCIATION

By

BRAMAN B. ADAMS AND RODNEY HITT

Associate Editors of the Railroad Gazette

UNDER THE SUPERVISION OF THE FOLLOWING COMMITTEE:

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RAILROAD AGE GAZETTE.

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RESOLUTION

Adopted by the Executive Committee of the Railway Signal Association, January 8, 1907, and approved by the Association at its annual meeting in Milwaukee, Wis., October 10, 1907:

"Whereas, The Railroad Gazette has proposed to publish under the direction of the Association, an illustrated dictionary of railroad signals and signaling; therefore, be it

"Resolved, That the Railroad Gazette be, and hereby is, authorized and empowered under the supervision of a committee of this Association to publish an illustrated dictionary of railroad signals and signaling."

The Executive Committee appointed as the supervising committee the members of the Association's Committee on Definitions, namely: Charles C. Anthony, Assistant Signal Engineer, Pennsylvania Railroad; Azel Ames, Jr., Signal Engineer, Electric Zone, New York Central & Hudson River Railroad; J. C. Mock, Electrical Engineer, Detroit River Tunnel Company.

PREFACE

Railroad signaling is a comparatively new art, and a rapidly growing one, so that its nomenclature is unsettled and its practices varied; and numerous changes of a somewhat radical nature are still going on. The development of scientific signaling, as distinguished from the earlier and empirical methods of controlling the movements of railroad trains, has proceeded from a curious combination of motives; in some cases, from the enterprise of trained men, in others from a pressing necessity due to expansion of business, and in still others to the force of public opinion, both the public and the railroad officer being sometimes actuated by injudicious haste. That we are not yet out of the transition state is no cause for surprise.

In making a signaling dictionary the very first step calls for arbitrary action. Hand-motion signaling, with or without the use of flags and lanterns, is excluded, because those features have no need of the services of the signal engineer. A "slow-board" is a fixed signal, but the signal engineer scarcely gives it a thought. On the other hand, automatic bells at highway crossings logically do not come under the head of railroad signals, for they do not directly affect the movement of trains; but the signal engineer does take cognizance of this class, because it requires skilled attention and is usually put in his charge.

In fixed signals, which constitute the subject of this work, American railroad officers often make a distinction which is wholly arbitrary and, in most cases, useless—that between interlocking signals and block signals. The function of a signal being clearly stated, the English nomenclature, ignoring this distinction, is entirely adequate. But to make each collection of drawings complete in itself, we recognize this distinction; and the reader will find—under the two different heads—different illustrations showing semaphore signals exactly alike.

Other uses of words are inexact, yet not troublesome. The noun "signal" usually means a semaphore signal complete, yet in speaking of the movements of a signal, especially where there are two arms on a single post, "signal" refers to the movable part alone. "Controlled manual" means signals worked by hand, but having the hand levers fitted with electric locks by which the man working the signals is subject to the control, under certain circumstances, of the signalman at another station, and also to control by the train itself through track circuits connected with the lever locks; but there are now at least three principal divisions of this subject, so that the simple term "controlled manual" has little meaning until it is explained. It includes: (1) A system worked without track circuits or any other means of control by trains; (2) one worked with a short track circuit at each block station, and (3) with a track circuit throughout the length of the block section.

Practice is more varied than nomenclature; but it is not so inconsistent as it seems, for with suitable limitations of the speeds of trains, supplemented by careful instruction of enginemen, the extreme requirements of the uniformity enthusiasts are not absolutely essential. For example, thousands of miles of railroad equipped with home block signals have very few distant signals, and this necessitates slackening of speed in snowstorms and fogs. Many block stations on single-track lines have but one signal for each direction, and both of these are supported on a single post, opposite the station office; but with a rule requiring trains to approach stations with speed under control, this arrangement is workable. On many roads this and other deficiencies of the block system are overcome by continuing in force the time-table regulations. The block system is a valuable means of safety even when worked under these modifications.

Semaphores have wholly superseded disks for signaling at yards and terminals, this for well-known reasons; but disks continue in favor on a few roads for automatic block signaling, and their use is not inconsistent with the use of semaphores. Likewise, the use of semaphores to be inclined upward to indicate "proceed," which is coming into vogue in a few places, is not inconsistent with the old practice, with the downward inclination.

In those drawings which show the color indications used in signals at night, "Green or White," referring to home signals, is to be read in connection with "Yellow or Green," referring to distant signals. Where green means clear, yellow is the color for caution in the distant signal (with an exception, as shown). The long-standing and general practice on American railroads at night is white for clear, green for caution, red for stop. The other scheme, green for clear, yellow for caution, red for stop, has come into favor within the past ten years (in England, green for clear became general nearly twenty years ago). Signal engineers are practically unanimous in their view that the abolition of "white" lights for giving signal indications is desirable everywhere.

A few American railroad companies, on their double-track lines, run trains on the left-hand track, notably the Lake Shore & Michigan Southern and the Chicago & North-Western. On these the arrangement of signals is like that shown in the view, Fig. 214, showing English practice, except that the arms are on the right of the posts.

This work, like the Car Builders' and the Locomotive dictionaries, is necessarily arranged in part like an encyclopedia, for on many subjects the drawings may be called the main feature and the text secondary; and in signaling, far more than in these other arts, extended explanation is necessary in connection with the drawings. The reader will at once recognize the propriety of the arrangement.

The Supervising Committee and the Editors warmly appreciate the courtesies of the railroad officers and manufacturers who have furnished drawings and information.

B. B. A.
R. H.

NEW YORK, March, 1908.

A BRIEF RETROSPECT

The block system was first used in America in 1863 or 1864, and interlocking about 1870. Both had been well developed on the busy railroads of England, so that American railroad officers could find there all necessary examples; but, with our lighter traffic, progress was rather slow. For many years the Pennsylvania, which in 1872 leased the lines east of Philadelphia, on which the block system had been first introduced, was the only road using it. A few roads in New England began using wire-circuit automatic block signals about 1871, but the time-interval rules were maintained in full force, so that the signals were of little use in increasing the capacity of the railroads. In 1879 the track circuit was introduced, making automatic block signals effective as against the danger of false clear signals being given by the accidental separation of a train into two parts (and incidentally affording a means of detecting broken rails), and from that time the use of the automatic system has progressed as fast as railroads have found themselves able to make the heavy investment necessary to install it. Automatic block signals are now in use on about 11,000 miles of American railroads.

Automatic block signals must work without the care of an attendant, and most of them at places remote from a source of power. They were first operated by a simple electro-magnet (the enclosed disk signal), the parts being made very light. To avoid the disadvantage of the glass enclosure the "clock-work" was next introduced, this apparatus furnishing power enough to move a disk exposed to wind, rain, snow and frost. Disks, however, were generally regarded as inferior to semaphores, and the next improvement was the electro-pneumatic mechanism, moving full-sized semaphores, which was introduced in 1885. This system, however, with its air pipe the whole length of every line which is signaled, is too costly for roads with any but the heaviest traffic, and it was not until the perfection of batteries and electric motors capable of economically operating full-size out-door semaphores (with an independent source of power at each signal) that automatic block signals became universally popular. Since 1900 the electric-motor signal has made great progress. The electro-gas signal has come into use to some extent as a competitor of the electric motor.

Until within the past five years single-track lines—with one exception, the Cincinnati, New Orleans & Texas Pacific—made little use of automatic signals, for there are peculiar difficulties on such lines. To make the signals efficient in preventing collisions between trains running in opposite directions the controlling circuits must be more extended and complicated than are those on double track, for each of two trains approaching each other must set signals at "stop" against the opposing train so far in advance of itself as to insure that both trains will receive stop indications in time to stop before meeting. And, in addition, when a train finds a signal at "stop" it must not proceed, as it would on double track, merely looking out for a train standing or moving in the same direction as itself, but must suffer considerable delay by sending a man ahead with a red flag or light, because there is the possibility that a train may be approaching in the opposite direction. In spite of these difficulties, however, automatic signals are being installed in large numbers on single-track lines by some companies.

Automatic signals reach their highest perfection in such installations as those on the New York subway and the Boston and the Philadelphia elevated roads where automatic stops are provided to guard against physical or mental disablement, or carelessness, on the part of the engineman or motorman. Because of the difficulty of maintaining this auxiliary apparatus on lines exposed to drifting snow and carrying a heavy miscellaneous traffic, and also because of the cost of maintenance and the reduction in the traffic capacity of the railroad, the automatic stop has not as yet been used except in special conditions like those of the roads named.

These city lines of dense traffic, worked by electric power, have also adopted costly inventions, marking notable scientific progress in signaling, made necessary by reason of the use of the rails of the track as conductors for the electric current which propels the trains. To work track-circuit signals on such tracks involves the use of many devices not used on ordinary railroads.

Going back now to non-automatic block signals, the first extension beyond the lines of the Pennsylvania (except about 15 miles on the New York Central) was on single-track lines west of the Alleghenies, where at first the "system" was little more than a rather informal order to telegraph operators to use their train-order signals as block signals. A train-order signal is ordinarily employed to stop, for the delivery of written despatcher's orders, trains which normally would proceed, regardless of the operator, on their time-table rights; and the change was simply to use these signals **to stop every train, unless the last preceding train had reached the next station,** this fact being reported by telegraph from the said next station. But this, simple as it was, and though frequently suspended as regards freight trains, was the essence of the main feature of the block system, and the results justified the practice. Block signaling is not complete and satisfactory without interlocking of all switches; nor without distant signals; nor (if not automatic) without sufficiently frequent stations to obviate the necessity of permissive signaling; but incomplete signaling has proved highly profitable. The least complete space interval system is

superior, both in safety and economy, to any scheme of time intervals, with its dependence on complicated rules, and the careful use of flags, torpedoes and fusees; on a high degree of vigilance in conductors and flagmen and the special skill of despatchers and station operators.

Since 1898 the use of manual block signaling has been quite rapidly extended throughout the country, and it now covers over 40,000 miles of road, besides several thousands more on which the protection is less complete. This manual signaling is on lines which carry a considerable traffic, but which yet are not profitable enough to justify the initial expenditure necessary to install automatic signals. But as fast as automatics can be afforded many companies are substituting them for the other system; for, once installed, their operation, requiring no signalmen, is much less costly.

This statement is not true, however, of the main lines of the New York Central and the New York, New Haven & Hartford, where (as well as to a slight extent elsewhere) there are manual signals with "control" apparatus—electric locks enabling one signalman to prevent errors by another. With this safeguard and with continuous track circuits as an auxiliary control, we have the highest present development of visual signaling. With automatic signals, enginemen will occasionally be careless because they are not watched, and with the simple manual system signalmen sometimes blunder; but with the "controlled manual" the presence of the signalmen keeps the enginemen vigilant and the machinery is an efficient check on the signalmen.

From the beginning, in 1870 or 1871, interlocking made slow but sure progress. In the large passenger terminals it was soon seen to be an absolute necessity, because without it the excessive cost of the wages of signalmen at detached switches, the danger of collisions due to imperfect hand-signaling and to fog, and the intolerable delays necessary to guard against these dangers, often put a serious embargo on traffic. The question of interlocking thus was largely one of economy rather than of safety, and the improvement was introduced mainly at terminal yards and junctions and crossings. (At crossings it economized time, fuel and wear by making unnecessary the stop for every train formerly required at all grade crossings). But as speeds of trains increased interlocking was found useful at all stations where much switching was done, for it obviates the slackening of the speed of fast trains, and our best lines now have interlocking for all their busiest stations.

Power operation of switches (and signals) familiarly termed "power interlocking" came into use with electro-pneumatic block signals. Following this, machines working wholly by electric power were tried as soon as electric motors were sufficiently developed, and the "low-pressure" pneumatic, with no electric apparatus, came soon after. The "all-electric" did not come into general use until about 1900; but it has now supplanted the "all-air." At small isolated plants it is economical because of the simplicity of the engine (gasoline) and generator necessary to produce the electric current.

This book is not a history; and, indeed, much of the best history in this field is too recent to be satisfactorily written; but the foregoing paragraphs will serve to give the reader who is not familiar with the subject some idea of the reasons for the existence of the extensive and varied art which is illustrated in the following pages. Signaling now engages the attention of the best engineering talent on all the best railroads. The signal manufacturing companies of the country employ millions of capital, and their engineers have met, and are meeting, innumerable abstruse and intricate problems, with brilliant success. American signalmen have accomplished both progress and economy, and new economies are still being effected.

DIRECTIONS
FOR USING
THE SIGNAL DICTIONARY

To find the meaning of a given word or term, refer to it in the alphabetical list, which constitutes the first part of the book, where will be found an ordinary dictionary definition and, where the subject is capable of illustration, a reference to some engraving in the second part of the book. The references to the engravings are usually by figure numbers, but in the case of a detail (which may appear in a number of drawings) a detail letter or number is used.

To find the name of any part of a signal or signal mechanism or apparatus, examine the Index to Engravings, on the pages immediately preceding the illustrated pages, looking for the class in which the object looked for belongs. Bear in mind the general divisions of the classification of Engravings, namely:

SIGNAL INDICATIONS; BLOCK SIGNALS; HIGHWAY CROSSING SIGNALS; INTERLOCKING; ACCESSORIES.

Having found the right class, and the engraving sought for, the name will be found either underneath the drawing or in the accompanying descriptive matter.

In the illustrations an asterisk (*) before the figure number indicates articles which are obtainable from a number of different manufacturers.

USE OF THE BLOCK SYSTEM IN THE UNITED STATES.

TABLE PUBLISHED BY THE INTERSTATE COMMERCE COMMISSION, JANUARY 1, 1908, SHOWING THE AGGREGATE LENGTH OF LINES OR PARTS OF LINES OF RAILROADS IN THE UNITED STATES ON WHICH THE BLOCK SYSTEM IS IN USE (MILES OF ROAD).

Names of railroads.	Automatic block signals, miles. Single track.	Automatic block signals, miles. Two or more tracks.	Automatic block signals, miles. Total.	Non-automatic block signals, miles. Single track.	Non-automatic block signals, miles. Two or more tracks.	Non-automatic block signals, miles. Total.	Total, all kinds	Total miles operated by company (passenger lines).	Per cent. operated under block system.
Ann Arbor	......	......	......	1.0	......	1.0	1.0	292.0	......
Atchison & Eastern Bridge	......	......	......	.4	......	.4	.4	.4	100.0
Atchison, Topeka & Santa Fe	......	20.2	20.2	1,144.3	327.5	1,471.8	1,492.0	7,480.3	19.9
Atlanta & West Point	......	......	......	......	6.0	6.0	6.0	87.0	14.5
Atlantic Coast Line	......	......	......	527.0	62.4	589.4	589.4	4,181.0	14.1
Baltimore & Ohio	11.2	131.6	142.8	222.9	689.1	912.0	1,054.8	2,964.5	35.6
Baltimore & Ohio Southwestern	......	......	......	8.7	50.7	59.4	59.4	981.0	6.0
Baltimore & Sparrow's Point	......	......	......	......	3.0	3.0	3.0	4.7	63.5
Bessemer & Lake Erie[1]	......	......	......	101.2	84.9	186.1	186.1	216.0	86.2
Boston & Maine	3.1	175.4	178.5	......	123.6	123.6	302.1	2,238.6	13.0
Buffalo, Rochester & Pittsburg	......	......	......	308.6	113.3	421.9	421.9	421.9	100.0
Caldwell & Northern	......	......	......	2.4	......	2.4	2.4	23.5	10.2
Camden Interstate	......	......	......	16.0	......	16.0	16.0	30.0	53.3
Central of Georgia	......	......	......	50.1	15.0	65.1	65.1	1,913.0	3.4
Central of New Jersey	13.0	199.4	212.4	......	......	......	212.4	475.8	44.6
Central Vermont	......	......	......	1.5	......	1.5	1.5	403.3	......
Chesapeake & Ohio	......	......	......	1,194.8	288.2	1,483.0	1,483.0	1,670.7	88.8
Chicago & Alton	170.3	141.1	311.4	351.4	37.9	389.3	700.7	904.2	77.5
Chicago & Eastern Illinois	3.6	103.5	107.1	169.4	57.5	226.9	334.0	693.0	49.5
Chicago & Northwestern	......	606.1	606.1	2,354.9	228.5	2,583.4	3,189.5	7,697.7	41.4
Chicago & Western Indiana	......	7.5	7.5	......	19.8	19.8	27.3	27.3	100.0
Chicago, Burlington & Quincy	......	36.3	36.3	8,289.1	523.4	8,812.5	8,848.8	8,968.2	98.7
Chicago Great Western	......	7.9	7.9	264.2	26.8	291.0	298.9	735.0	40.7
Chicago, Milwaukee & St. Paul	5.9	38.0	43.9	4,167.6	385.4	4,553.0	4,596.9	6,550.2	70.2
Chicago, Rock Island & Pacific	1.0	152.1	153.1	752.0	118.6	870.6	1,023.7	6,679.8	15.3
Chicago, St. Paul, Minneapolis & Omaha	......	6.4	6.4	591.6	64.1	655.7	662.1	1,486.5	44.5
Chicago Terminal Transfer	......	5.4	5.4	......	......	......	5.4	46.1	11.7
Cincinnati & Muskingum Valley	......	......	......	11.4	......	11.4	11.4	148.4	7.7
Cincinnati, Hamilton & Dayton	......	......	......	73.0	27.9	100.9	100.9	907.0	11.0
Cleveland, Akron & Columbus	......	......	......	11.0	8.0	19.0	19.0	177.4	10.7
Cornwall & Lebanon	......	......	......	8.3	13.7	22.0	22.0	22.0	100.0
Cumberland & Pennsylvania	......	......	......	4.3	3.0	7.3	7.3	31.3	23.3
Cumberland Valley	......	......	......	18.8	10.1	28.9	28.9	163.2	17.7
Davenport, Rock Island & Northwestern	......	......	......	40.6	1.1	41.7	41.7	41.7	100.0
Delaware & Hudson	177.2	230.4	407.6	.6	......	.6	408.2	743.9	54.8
Delaware, Lackawanna & Western	1.4	465.1	466.5	......	......	......	466.5	859.2	54.3
Erie	......	73.6	73.6	643.5	623.9	1,267.4	1,341.0	1,744.6	77.0
Chicago & Erie	......	......	......	240.4	8.4	248.8	248.8	248.8	100.0
New Jersey & New York	......	10.5	10.5	26.1	......	26.1	36.6	51.8	70.0
New York, Susquehanna & Western and Wilkesbarre & Eastern	......	......	......	......	20.7	20.7	20.7	236.1	8.0
Grand Rapids & Indiana	......	......	......	......	2.2	2.2	2.2	436.5	0.5
Grand Trunk Railway System:									
International boundary to Black Rock Junction	......	......	......	0.7	......	0.7	0.7	0.7	100.0
Atlantic & St. Lawrence	......	......	......	165.1	......	165.1	165.1	165.1	100.0
Grand Trunk Western	......	......	......	7.0	323.9	330.9	330.9	330.9	100.0
Michigan Air Line	......	......	......	105.6	......	105.6	105.6	105.6	100.0
Detroit, Grand Haven & Milwaukee	......	......	......	185.5	3.5	189.0	189.0	189.0	100.0
Chicago, Detroit & Canada Grand Trunk Junction	......	......	......	54.7	2.7	57.4	57.4	57.4	100.0
St. Clair Tunnel	2.0	......	2.0	......	......	......	2.0	2.0	100.0
Grand Rapids Terminal	......	......	......	1.1	0.4	1.5	1.5	1.5	100.0
Great Northern	6.2	62.0	68.2	252.1	......	252.1	320.3	6,168.0	5.2
Hocking Valley	......	......	......	74.7	......	74.7	74.7	338.5	22.1
Illinois Central	28.0	239.9	267.9	783.9	......	783.9	1,051.8	5,598.1	18.8
Iowa Central	......	......	......	27.8	......	27.8	27.8	394.4	7.0
Kentucky & Indiana Bridge & Railroad Co.	......	......	......	7.2	3.4	10.6	10.6	20.0	53.0
Lackawanna & Wyoming Valley	......	......	......	1.0	2.4	3.4	3.4	22.6	15.0
Lehigh Valley[2]	14.1	456.4	470.5	695.6	54.8	750.4	1,220.9	1,141.9	100.0
Long Island	4.0	68.9	72.9	......	22.7	22.7	95.6	392.0	24.4
Louisville & Nashville	7.0	......	7.0	445.5	38.8	484.3	491.3	3,775.0	13.0
Maine Central	62.3	29.2	91.5	......	......	......	91.5	910.6	10.1
Missouri Pacific	126.0	23.9	149.9	226.6	3.3	229.9	379.8	5,212.6	7.3
Mobile & Ohio	......	4.7	4.7	42.4	......	42.4	47.1	825.0	9.6
Monongahela	0.5	......	0.5	......	......	......	0.5	53.6	0.9
Monongahela Connecting	......	......	......	......	4.0	4.0	4.0	55.0	8.0
Nashville, Chattanooga & St. Louis	......	......	......	89.8	7.2	97.0	97.0	1,236.5	7.8
New York & Long Branch	......	38.0	38.0	......	......	......	38.0	38.0	100.0
New York Central Lines:									
New York Central & Hudson River	......	143.6	143.6	1,734.4	953.6	2,688.0	2,831.6	2,843.5	99.5
Boston & Albany	......	171.2	171.2	......	2.9	2.9	174.1	352.3	49.4
Michigan Central	......	272.0	272.0	984.4	19.1	1,003.5	1,275.5	1,275.5	100.0
Lake Shore & Michigan Southern	......	499.6	499.6	950.3	43.6	993.9	1,493.5	1,493.5	100.0
Cleveland, Cincinnati, Chicago & St. Louis	......	......	......	582.8	290.2	873.0	873.0	1,762.7	49.5
Lake Erie & Western	......	......	......	9.7	8.9	18.6	18.6	827.0	2.3
Pittsburgh & Lake Erie	......	140.1	140.1	28.5	2.9	31.4	171.5	190.7	90.0
Chicago, Indiana & Southern	......	2.0	2.0	16.7	......	16.7	18.7	301.4	6.0
New York, New Haven & Hartford	23.3	228.3	251.6	395.0	280.9	675.9	927.5	2,029.2	46.4
New York, Ontario & Western	31.9	102.9	134.8	......	......	......	134.8	492.8	27.3
Norfolk & Western	1.1	29.3	30.4	1,506.7	205.5	1,712.2	1,742.6	1,829.3	95.3
Northern Pacific	3.9	15.0	18.9	886.6	224.9	1,111.5	1,130.4	4,975.5	22.7
Pennsylvania Railroad	......	237.4	237.4	1,084.4	903.0	1,987.4	2,224.8	3,184.0	69.8
Pennsylvania Company	17.8	90.2	108.0	216.4	544.1	760.5	868.5	1,305.4	66.5
Pittsburgh, Cincinnati, Chicago & St. Louis	......	7.2	7.2	603.7	485.9	1,089.6	1,096.8	1,408.5	77.8
Philadelphia, Baltimore & Washington	......	33.0	33.0	20.2	187.0	207.2	240.2	646.7	37.1
Northern Central	......	......	......	287.2	125.6	430.5	430.5	440.0	97.8
West Jersey & Seashore	......	91.2	91.2	51.6	29.1	80.7	171.9	291.1	59.0
Peoria & Pekin Union	......	......	......	6.2	6.5	12.7	12.7	16.7	76.0
Pere Marquette	6.1	......	6.1	29.3	......	29.3	35.4	1,917.5	1.8
Philadelphia & Reading[3]	4.3	339.1	343.4	98.2	125.1	223.3	566.7	846.9	65.3
Atlantic City	......	86.7	86.7	23.5	......	23.5	110.2	152.9	72.1
Northeast Pennsylvania	2.9	1.9	4.8	1.7	......	1.7	6.5	25.9	25.1
Perkiomen	......	......	......	38.3	......	38.3	38.3	38.3	100.0
Philadelphia & Frankford	2.6	......	2.6	......	......	......	2.6	2.6	100.0
Philadelphia, Newton & New York	4.2	3.5	7.7	......	......	......	7.7	22.2	34.7
Reading & Columbia	......	......	......	35.7	......	35.7	35.7	53.3	67.0
Queen & Crescent Route:									
Alabama Great Southern	45.6	......	45.6	......	1.5	1.5	47.1	290.5	16.2
Cincinnati, New Orleans & Texas Pac.	272.1	56.3	328.4	5.5	......	5.5	333.9	335.9	99.4
Richmond, Fredericksburg & Potomac	......	......	......	9.8	77.9	87.7	87.7	87.7	100.0
St. Louis & San Francisco	25.0	16.2	41.2	331.3	16.5	347.8	389.0	4,767.2	8.1
St. Louis Merchants Bridge Terminal	......	5.7	5.7	......	1.1	1.1	6.8	9.9	69.0
San Pedro, Los Angeles & Salt Lake	1.1	......	1.1	......	......	......	1.1	1,066.4	......
Seaboard Air Line	......	......	......	210.1	......	210.1	210.1	2,436.5	8.6

(Continued on following page.)

BLOCK SIGNAL MILEAGE—Continued

Names of railroads.	Automatic block signals, miles. Single track.	Two or more tracks.	Total.	Non-automatic block signals, miles. Single track.	Two or more tracks.	Total.	Total, all kinds.	Total miles operated by company (passenger lines).	Per cent. operated under block system.
Southern	......	......	......	1,388.8	205.2	1,594.0	1,594.0	5,920.6	26.9
St. Louis-Louisville Lines	......	......	......	148.6	1.0	149.6	149.6	515.7	29.0
Southern Illinois & Missouri Bridge	......	4.6	4.6	......	......	......	4.6	4.6	100.0
Southern Pacific-Atlantic System:									
Texas & New Orleans	106.7	......	106.7	......	......	......	106.7	438.7	24.3
Louisiana Western	103.6	......	103.6	......	......	......	103.6	140.3	73.9
Morgan's Louisiana & Texas	94.4	......	94.4	......	......	......	94.4	282.0	33.5
Galveston, Harrisburg & San Antonio	39.5	......	39.5	......	......	......	39.5	1,275.5	3.1
Southern Pacific—Pacific System	1,621.0	132.0	1,753.0	102.3	......	102.3	1,855.3	5,766.3	32.2
Staten Island Rapid Transit	1.3	7.0	8.3	8.9	11.7	20.6	28.9	28.9	100.0
Terminal Railroad Association of St. Louis	......	6.0	6.0	......	1.1	1.1	7.1	12.6	56.3
Ulster & Delaware	25.0	......	25.0	......	......	......	25.0	126.3	19.8
Union	......	0.6	0.6	2.4	......	2.4	3.0	7.4	40.5
Union Pacific	819.5	359.0	1,178.5	11.1	......	11.1	1,189.6	2,917.0	40.8
Oregon Short Line	176.8	......	176.8	......	......	......	176.8	1,368.9	12.9
Oregon Railroad & Navigation Co.	297.0	......	297.0	......	......	......	297.0	1,248.6	23.8
Vandalia	......	......	......	216.6	22.0	238.6	238.6	796.7	30.0
Wabash	......	19.6	19.6	1,726.7	113.8	1,840.5	1,860.1	1,987.1	93.6
Wabash Pittsburgh Terminal	......	4.8	4.8	......	......	......	4.8	63.5	7.4
Washington Southern	......	......	......	......	34.2	34.2	34.2	34.2	100.0
Wisconsin Central	......	......	......	......	4.4	4.4	4.4	783.2	0.5
Total	4,363.5	6,439.5	10,803.0	38,517.0	9,358.7	47,875.7	58,678.7	151,455.2	......

[1]Manual block system on 8.9 miles used exclusively by freight trains not shown in this table.
[2]Automatic signals in addition to telegraph block on 6.6 miles.
[3]Automatic block signals on 16.3 miles used exclusively by freight trains not shown in this table.

The columns headed "Two or More Tracks" include a few lines of road on which there are three main tracks, and the following lines of four-track:

MILES OF FOUR-TRACK RAILROAD.

	Automatic block signals.	Manual block signals.
Baltimore & Ohio	...	18
Boston & Albany	19	...
Central of New Jersey	30	...
Delaware & Hudson	17	...
Erie	14	...
Illinois Central	12	...
Lake Shore & Michigan Southern	120	...
Lehigh Valley	11	...
New York Central & Hudson River	15	306
New York, New Haven & Hartford	...	62
Northern Central	...	18
Pennsylvania	188	200
Pennsylvania Lines west of Pittsburgh	32	31
Philadelphia, Baltimore & Washington	21	11
Philadelphia & Reading	16	...
Pittsburgh & Lake Erie	31	...
	526	646

Certain roads which do not appear in the foregoing table have block-signaled lines as follows:

	Automatic miles of road.	Manual miles of road.
Boston Elevated	9.0	...
Boston, Revere Beach & Lynn	13.2	...
Duluth, South Shore & Atlantic	...	4.2
Hudson & Manhattan (Hoboken and New York)	3.0	...
Interborough Rapid Transit (New York City)	13.5	...
Northwestern Pacific (North Shore)	10.0	...
Philadelphia Rapid Transit	5.0	...
Philadelphia & Western	11.5	...

From data given in the government report it appears that on 40,040 miles of line worked by manual block signals (out of the total of 47,876 miles) the signaling is regulated by the use of the Morse telegraph; on 3,287 miles it is done by means of telephones; on 839 miles by electric bells; on about 2,400 miles by controlled manual apparatus, without track circuits; on 727 miles by controlled manual apparatus, with track circuits at stations; on 212 miles by controlled manual apparatus, with track circuits continuous throughout the block sections, and on 234 miles by the electric train staff.

The principal roads using telephones for block signaling are the Atchison, Topeka & Santa Fé, 1,438 miles (including some double track); Chicago, Burlington & Quincy, 753 miles (including some double track); Illinois Central, 769 miles; Michigan Central, 68 miles; Pennsylvania, 203 miles (including some double track); West Jersey & Sea Shore, 29 miles (all double track).

The principal road using electric bells (not controlled manual) is the Erie, on which there are 722 miles worked in this way, including both double track and single track lines. Other lines are the Long Island, the Pennsylvania and the Wabash.

The principal roads using controlled manual, with no track circuits, are the Chesapeake & Ohio, 147 miles; Chicago & Eastern Illinois, 69 miles; Chicago, Burlington & Quincy, 1,252 miles; Illinois Central, 769 miles. Nearly all of this mileage is single track.

The roads using controlled manual, with track circuits at the stations, are the Chesapeake & Ohio, 92 miles; Chicago & Alton, 19 miles; Long Island, 8.6 miles; New York Central & Hudson River, 373 miles; New York, New Haven & Hartford, 229 miles.

The roads using controlled manual, with continuous track circuits, are the Chesapeake & Ohio, 29 miles; Chicago, Burlington & Quincy, 61 miles; New York Central & Hudson River, 70 miles (234 miles of *track*); Pennsylvania, 14 miles. The electric train staff is in use on 20 roads, but only five of these have more than 10 miles each. These five are the Atchison, Topeka & Santa Fé, 34 miles; Chicago & Alton, 18 miles; Great Northern, 15 miles; Southern Pacific, 101 miles; Union Pacific, 11 miles.

The 100 roads on which manual block signals are in use report the number of block signal stations as 9,438, and 2,600 of these stations (on 62 roads) are closed part of the time. Among the roads which do not report any block stations as being closed a part of the time are the Illinois Central; the New York, New Haven & Hartford; the Pittsburgh, Cincinnati, Chicago & St. Louis. and the Vandalia.

The following mileage, reported by the roads named, is given as being worked by the block system for passenger trains only:

Buffalo, Rochester & Pittsburgh...	422 miles
Michigan Central	1,003 "

On the following sections of single-track road the block system (manual) is used only for the protection of trains from rear collisions:

Chicago, Burlington & Quincy....	5,165 miles
Michigan Central	1,003 "
Missouri Pacific	227 "
Norfolk & Western	727 "
Northern Central	187 "
Wabash	773 "

On 23,196 miles of road worked by the manual block system most, or all, of the block stations have but one signal each for movements in each direction. This signal is usually fixed opposite the station office, and trains ordinarily are allowed to pass a signal indicating "stop" sufficiently far to stop the cars at the station platform. About 3,600 miles of the lines here referred to are double track.

KINDS OF AUTOMATIC BLOCK SIGNALS IN USE IN THE UNITED STATES

TABLE PUBLISHED BY THE INTERSTATE COMMERCE COMMISSION
JANUARY 1, 1908

Names of railroads.	Uninclosed disks ("clock-work").		Inclosed disks.		Semaphores.						Normal clear, miles of track.	Normal danger, miles of track.	Total automatic signals.	
					Electro-pneumatic.		Electric motor.		Electro-gas.					
	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.	Miles of road.	Miles of track.			Miles of road.	Miles of track.
Alabama Great Southern	14.5	14.5					31.1	31.1			45.6		45.6	45.6
Atchison, Topeka & Santa Fe			4.6	9.2			15.6	31.2			40.4		20.2	40.4
Atlantic City			86.7	173.4							173.4		86.7	173.4
Baltimore & Ohio			9.5	9.5			39.1	76.2	94.2	188.4	12.6	261.5	142.8	274.1
Boston & Albany	120.2	247.0	10.0	40.0			28.0	67.8	13.0	26.0	314.8	66.0	171.2	380.8
Boston & Maine	20.6	41.2	1.3	3.1			147.7	270.0	8.9	17.8	312.7	19.4	178.5	332.1
Central of New Jersey					29.7	116.0	163.3	318.6	19.4	38.0	434.6	38.0	212.4	472.6
Chicago & Alton							311.4	452.5			135.8	316.7	311.4	452.5
Chicago & Eastern Illinois			8.7	13.8			98.4	196.8			[a] 210.6		107.1	210.6
Chicago & Northwestern			599.8	1,216.0	6.3	12.6					1,229.5		606.1	1,229.5
Chicago & Western Indiana							7.5	[a] 15.0			15.0		7.5	15.0
Chicago, Burlington & Quincy			26.9	53.8	5.5	22.0	3.9	3.9			75.8	3.9	36.3	79.7
Chicago Great Western							7.9	15.8			15.8		7.9	15.8
Chicago, Indiana & Southern							2.0	4.0				4.0	2.0	4.0
Chicago, Milwaukee & St. Paul			5.7	9.0			34.7	69.4	3.5	3.5	68.4	13.5	43.9	81.9
Chicago, Rock Island & Pacific			7.9	15.0			145.0	290.0	0.2	0.2	305.2		153.1	305.2
Chicago, St. Paul, Minneapolis & Omaha							6.4	12.8			12.8		6.4	12.8
Chicago Terminal Transfer			1.0	2.0	3.2	6.4	1.2	2.4			10.8		5.4	10.8
Cincinnati, New Orleans & Texas Pacific	39.0	39.0	56.1	56.1			228.3	281.6	5.0	8.0	382.9	1.8	328.4	384.7
Delaware & Hudson			37.8	75.6					369.8	601.6		677.2	407.6	677.2
Delaware, Lackawanna & Western			11.0	20.6			445.5	897.1			917.7		456.5	917.7
Erie							73.6	175.6				175.6	73.6	175.6
Galveston, Harrisburg & San Antonio			1.7	1.7			37.8	37.8			39.5		39.5	39.5
Great Northern			68.2	130.2							127.0	3.2	68.2	130.2
Illinois Central			25.9	63.6			78.0	146.8	157.4	314.7	373.6	151.5	261.3	525.1
Lake Shore & Michigan Southern			5.1	10.2			319.0	714.4	175.5	585.2	724.6	585.2	499.6	1,309.8
Lehigh Valley			262.8	550.2			193.6	404.7	14.1	28.2		983.1	470.5	983.1
Long Island							72.9	149.2			145.2	4.0	72.9	149.2
Louisiana & Western							103.6	103.6			103.6		103.6	103.6
Louisville & Nashville							7.0	7.0			7.0		7.0	7.0
Maine Central							91.5	120.7			120.7		91.5	120.7
Michigan Central			97.3	194.6			174.7	349.4			544.0		272.0	544.0
Missouri Pacific							149.9	173.8			173.8		149.9	173.8
Mobile & Ohio							4.7	9.5			9.5		4.7	9.5
Monongahela							0.5	0.5			0.5		0.5	0.5
Morgan's Louisiana & Texas							94.4	94.4			94.4		94.4	94.4
New Jersey & New York							10.5	21.0				21.0	10.5	21.0
New York & Long Branch							38.0	76.0			76.0		38.0	76.0
New York Central & Hudson River			11.2	22.4			124.3	277.6	8.1	16.2	316.2		143.6	316.2
New York, New Haven & Hartford	168.5	315.0	64.2	128.4			18.9	36.5			479.9		251.6	479.9
New York, Ontario & Western	134.8	237.7									237.7		134.8	237.7
Norfolk & Western							18.5	37.0			37.0		18.5	37.0
Northeast Pennsylvania			4.8	6.7								6.7	4.8	6.7
Northern Pacific			8.0	4.5			11.4	22.8	4.5	6.6	25.5	8.4	18.9	33.9
Oregon Railroad & Navigation Co			2.0	2.0			295.0	295.0			297.0		297.0	297.0
Oregon Short Line			22.3	22.3			154.5	154.5			176.8		176.8	176.8
Pennsylvania			4.5	9.0	227.2	834.6	5.7	11.4			855.0		237.4	855.0
Pennsylvania Company							108.0	274.1			274.1		108.0	274.1
Pere Marquette			3.2	3.2			2.9	2.9			6.1		6.1	6.1
Philadelphia & Frankford			2.6	2.6								2.6	2.6	2.6
Philadelphia & Reading			344.8	757.7	0.7	1.4			14.2	20.5	0.6	779.0	[b] 359.7	779.6
Philadelphia, Baltimore & Washington					33.0	108.0					108.0		33.0	108.0
Philadelphia, Newton & New York			7.7	16.7								16.7	7.7	16.7
Pittsburg & Lake Erie							140.1	350.2			350.2		140.1	350.2
Pittsburg, Cincinnati, Chicago & St. Louis							7.2	14.4			14.4		7.2	14.4
St. Louis & San Francisco			8.0	11.0			33.2	46.4			56.4	1.0	41.2	57.4
St. Louis Merchants Bridge Terminal							5.7	11.4			11.4		5.7	11.4
St. Clair Tunnel					2.0	2.0						2.0	2.0	2.0
San Pedro, Los Angeles & Salt Lake							1.1	1.1			1.1		1.1	1.1
Southern Illinois & Missouri Bridge							4.6	9.3			9.3		4.6	9.3
Southern Pacific Co.: Pacific System			2.4	2.4	6.0	13.7	1,744.6	1,870.9			1,887.0		1,753.0	1,887.0
Staten Island Rapid Transit			8.3	15.3								15.3	8.3	15.3
Syracuse, Binghamton & New York			10.0	20.0							20.0		10.0	20.0
Terminal Railroad Association of St. Louis							6.0	12.0			12.0		6.0	12.0
Texas & New Orleans							106.7	106.7			106.7		106.7	106.7
Ulster & Delaware							25.0	25.0			25.0		25.0	25.0
Union			0.6	1.2							1.2		0.6	1.2
Union Pacific			10.4	20.8			1,132.8	1,450.5	35.3	70.6	1,541.9		1,178.5	1,541.9
Wabash							19.6	39.2			39.2		19.6	39.2
Wabash Pittsburgh Terminal							4.8	9.6			9.6		4.8	9.6
West Jersey & Seashore					91.2	194.4					194.4		91.2	194.4
Yazoo & Mississippi Valley							6.6	6.6			6.6		6.6	6.6
Total	497.6	894.4	1,838.0	3,694.7	404.8	1,311.1	7,143.9	10,685.7	923.1	1,925.5	14,354.1	4,157.3	10,807.4	18,511.4

CLASSIFIED INDEX TO ADVERTISEMENTS

(For Alphabetical Index see page following last page of illustraticns.)

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General Railway Signal Co., Rochester, N. Y.
Hall Signal Co., New York, N. Y.
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INSULATED STANDARD SECTION RAIL JOINTS: (See Rail Joints, Insulated.)

INSULATED STEP OR COMPROMISE RAIL JOINTS:
Rail Joint Co., New York, N. Y.

INSULATED WIRE:
Atlantic Ins. Wire & Cable Co., New York, N. Y.
Brixey, W. R., New York, N. Y.
Central Electric Co., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
General Railway Signal Co., Rochester, N. Y.
Hazard Mfg. Co., Wilkes-Barre, Pa.
Union Switch & Signal Co., Swissvale, Pa.
Western Wire Sales Co., Chicago, Ill.

INSULATING TAPE:
(See Tape.)

INSULATION:
American Railway Signal Co., Cleveland, O.
Atlantic Ins. Wire & Cable Co., New York, N. Y.
Brixey, W. R., New York, N. Y.
Bryant Zinc Co., Chicago, Ill.
Central Electric Co., Chicago, Ill.
Continental Signal Co., Chicago, Ill.
Eureka Auto-Elec. Signal Co., Tamaqua, Pa.
General Electric Co., Schenectady, N. Y.
General Railway Signal Co., Rochester, N. Y.
Hall Signal Co., New York, N. Y.
Johns-Manville Co., H. W., New York, N. Y.
McClintock Mfg. Co., St. Paul, Minn.
Rail Joint Co., New York, N. Y.
Railroad Supply Co., Chicago, Ill.
Stiles Co., T. Geo., Arlington, N. J.
Union Switch & Signal Co., Swissvale, Pa.
U. S. Electric Signal Co., West Newton, Mass.

INSULATORS (GLASS):
Central Electric Co., Chicago, Ill.

INSULATORS (PORCELAIN):
Central Electric Co., Chicago, Ill.
General Electric Co., Schenectady, N. Y.

INTERLOCKING FITTINGS:
American Railway Signal Co., Cleveland, O.
Bossert Mfg. Co., Inc., W. F., Utica, N. Y.
Buffalo Railway Supply Co., Buffalo, N. Y.
Continental Signal Co., Chicago, Ill.
General Railway Signal Co, Rochester, N. Y.
Hall Signal Co., New York, N. Y.
McClintock Mfg. Co., St. Paul, Minn.
Stiles Co., T. Geo., Arlington, N. J.
Union Switch & Signal Co., Swissvale, Pa.

INTERLOCKING MACHINES:
American Railway Signal Co., Cleveland, O.
Continental Signal Co., Chicago, Ill.
General Railway Signal Co., Rochester, N. Y.
Stiles Co., T. Geo., Arlington, N. J.
Union Switch & Signal Co., Swissvale, Pa.

IRON AND STEEL WIRE (BARE AND WEATHERPROOF):
Brixey, W. R., New York, N. Y.
Central Electric Co., Chicago, Ill.

CLASSIFIED INDEX TO ADVERTISEMENTS

A DICTIONARY OF
American Railroad Signaling

A

Absolute Block Signaling. The rigid adherence to the fundamental principle of the block system that no train be admitted to a block while another train occupies it. See **Permissive Block Signaling.**

A. C. Abbreviation for Alternating Current.

Accumulator. See **Storage Battery.**

Adjustable Crank. See Figs. 1109-1110.

Adjustable Lock Rod. See Figs. 932-937.

Adjusting Screw. A device in a pipe or wire line used for changing its length, as in case of expansion or contraction due to higher or lower temperature. See Figs. 1013-1016, 1299-1300.

Advance (adjective). In an advanced position, as a signal, as related to the train for which such signal is used. A train approaching a station which has a distant, a home and an advance signal, encounters firist the distant, then the home and then the advance. The distant is in the rear of the home, and the home is in the rear of the advance signal.

Advance Signal. A signal having the same function as a home signal, placed some distance in advance of the home signal at a block or interlocking signal station, providing in effect a short block section in which the signalman may hold a train while not interfering with the movement of trains in the main block section, either in advance or in the rear. He can accept another train the rear block as soon as the arriving train has passed completely beyond his home signal, and he can hold the arriving train at the advance signal until the block in advance is clear. In Great Britain a signalman is forbidden, except under rigid restrictions, to authorize a train to proceed toward his station from the station in the rear, unless the last preceding train has passed beyond his starting signal; or, if there is no such signal, until it has passed 1,320 ft. (¼ mile) beyond his home signal. The restriction is that he must give to the rear station a special authorization, "section clear, but station or junction blocked," and this information must be given to the engineman by word of mouth. See Figs. 224-225, 638-641, 658.

Advance Starting Signal. (British.) See **Starting Signal.**

Air Gap. The space between the ends of the poles of an electro-magnet and the armature of the magnet. Any break occupied wholly by air in a magnetic circuit.

Alligator Jaw. See **Escapement Crank.**

"All Right." An oral signal commonly given by a conductor to an engineman, meaning proceed to the next station or regular stopping place; used also, loosely, in speaking of the "proceed" indication of a fixed signal. In British practice the oral signal, "right away," has a meaning similar to the American "all-right."

Alternating Current. A current of electricity which flows alternately in opposite directions, as distinguished from a continuous or **Direct Current,** which see, which flows constantly in the same direction through a circuit. The number of alternations or changes of direction per second is termed the frequency, and in commercial application varies from 25 to 120. The complete change from maximum negative through maximum positive and back to maximum negative is a cycle, and the frequency is expressed in so many cycles per second. A single current alternately changing direction is a single-phase current. A two-phase current consists of two single-phase currents flowing in opposite directions at the same instant, and a three-phase current consists of three single-phase currents one-third of a cycle apart. Three-phase current requires for its transmission three separate wires, the current flowing in one wire at any instant, being equal in electro-motive force to the algebraic sum of the electro-motive forces of the currents flowing in the other two wires, but opposite in direction.

Alternating Current Relay. A relay designed to respond to alternating current. See Figs. 496-497, 521-522,530-534, 539.

Ammeter. An instrument for measuring in terms of amperes, the current flowing in an electrical circuit. It consists of a fixed coil of heavy wire carrying the current to be measured and a pivoted magnetic core to which, is attached a pointed sweeping over a fixed scale. The force tending to displace this core from its normal position varies with the current passing through the coil and is resisted by some opposing force, usually gravity, a spring or a powerful permanent magnet, which brings the pointer into a new position of equilibrium for each value of the current. See Figs. 2932, 2935-2937, 2949, 2950.

Ampere. The practical unit of measurement of electric current or the rate of flow. Such a current as will pass with an electro-motive force of one volt through a circuit of one ohm resistance. The analogy of water flowing through a pipe will make this clear. That which causes the water to flow is the pressure or head; that which resists the flow is the friction of the water against the pipe, and the rate of flow may be represented by so many cubic inches of water per second. Electrically, the pressure corresponds to electro-motive force, the friction to resistance and the quantity or the number of amperes to the rate of flow. As the pressure increases the flow increases proportionally; as the resistance increases the flow decreases. The relation between amperes, volts and ohms is represented by Ohm's law, $I = \frac{E}{R}$, in which I is the current, R the resistance and E the electro-motive

force. The standard of measurement for an ampere is such a current as will deposit 4.024 grammes of silver in one hour on one of the plates of a silver voltameter from a solution of silver nitrate containing from 15 to 30 per cent. of the salt

Angle of Lag. An angle whose tangent is equal to the ratio of the inductive to the ohmic resistance of a circuit. An angle whose cosine is equal to the ohmic resistance of a circuit divided by the impedance of the circuit. An angular difference between any point on the current curve of an A. C. circuit and a corresponding point on the potential curve of the same circuit.

Annunciator. A device, audible or visual, to announce the approach of a train. Visual annunciators are either of the drop type or of the same general form and appearance as indicators; Figs. 2019, etc. Audible enunciators are usually electric bells. See **Approach Indicator.**

Apparent Resistance. Phenomena due to impedance, reactance, inductance, capacity and ohmic resistance of an A. C. circuit, and appearing as a factor similar to the ohmic resistance of a D. C. circuit.

Approach Indicator. A block indicator for an approach locking or other track circuit.

Approach Locking. Electric locking effected by the approach of a train, the train actuating a track-circuit relay or a track instrument. The arrangement is such that the levers are locked as soon as a train approaches the signals; that is, while it is yet some distance away, say one or two miles. If an approaching train by this means locks switches and then is stopped and detained and does not use the route, the signalman can unlock his levers by closing the unlocking circuit by means of a "time release." The releasing device is arranged to enforce deliberation (and thus prevent errors) by an automatic time device; by a slow-moving circuit closer operated by making a number of turns of a screw; or by a hand switch fixed in some inaccessible place, requiring some time for the signalman to get to it. Thus the signalman will be prevented from hastily taking away a route which has been set up tor an approaching train. Approach locking may be used for only one or two movements through an interlocking, or it may be expanded to cover any possible movement. Typical approach locking circuits are shown and explained in Figs. 1996-2008, 2013. See **Screw Release, Electric Lock, Time Release.**

A. R. A. Abbreviation for American Railway Association.

Arm. The principal movable part of a semaphore, consisting of a blade, usually of wood, fastened to a casting, which turns on the supporting pivot. See Figs. 129, etc.

Arm Casting. That part of a semaphore arm which contains the bearing and the spectacles for holding the glasses which give the right color indications. To it is fastened the blade

Arm Sweep. The segment of a circle defining the limits of the movement of a semaphore signal arm.

Armature. A mass of iron or other magnetizable material placed on or near the pole or poles of a magnet. In the case of a permanent magnet the armature, when used as a keeper, is of soft iron, and is placed directly on the magnetic poles. In this case it preserves or keeps the magnetism by closing the lines of magnetic force of the magnet through the soft iron of the armature and is then called a keeper. In the case of an electro-magnet the armature is placed near the poles and is moved toward them whenever the magnet is energized by the passage of the current through the magnetizing coils. This movement is made against the action of a spring or gravity, so that on the loss of magnetism by the magnets, the armature moves from the magnetic poles. When the armature is of soft iron it moves toward the magnet on the completion of the circuit through its coils, no matter in what direction the current flows, and is then called a non-polarized or neutral armature. When made of steel or of another electro-magnet it moves from or toward the poles according to whether the poles of the armature are of the same or of a different polarity from those of the magnet. Such an armature is called a polarized armature (Houston). The term armature is applied to the rotor or stator of a motor or generator. See **Magnet.**

Automatic Block Signal. A block signal, worked by electric or pneumatic agency, which is controlled by the passage of a train into, through and out of the block section to which the signal is connected. The entrance of a train sets the home signal at stop, and the clearing of the block section by the passage of the train out of it sets that signal clear. The apparatus is so arranged that the misplacement of a switch or the accidental entrance of a car from a side track will set the signal at stop. See **Track Circuit, Distant Signal.**

Automatic Block Signal System. A series of consecutive blocks. Automatic block signals were invented and developed in America, the first installation being 16 miles of the Eastern Railroad of Massachusetts (now the Boston & Maine) equipped with automatic signals in 1871. These signals were controlled by **Track Instruments,** which see. In 1879 the **Track Circuit,** which see, was introduced as a method of control on 10 miles of the Fitchburg Railroad, and is now universally used in automatic signaling.

Automatic Stop. An apparatus, mechanical or electro-magnetic, for stopping trains by means actuated from outside the train (as at a signal post). In the simplest form a trip, fixed on the roadway and moving in unison with the usual visual signal, is made to open an air-valve on the engine, or car, thereby applying the power brakes or shutting off the propelling power, or both, independently of the engineman or motorman. See Figs. 509, 515, 525, 536, 550, 551, 558, 2960-2670.

B

B. W. G. Abbreviation for Birmingham Wire Gage.

B. & S. Abbreviation for Brown & Sharpe's Wire Gage.

Back Contact. (Of a Relay.) An electric contact which is made by the armature of a relay when it falls away from the pole piece of the magnet coils consequent on the cessation of the current flowing through the coils. See **Relay** and **Front Contact.**

Back Light. A small glass-covered opening in the back of a signal lamp. It is to enable the signalman to keep watch of the light and be assured that it is always burning. The back light (spectacle) on the semaphore arm, usually carries a purple glass, so arranged that when the signal is at stop the back light shows purple, and when it is pulled off the back light shows white.

Back Locking. The mechanical locking in a "Standard" interlocking machine, which acts in the same plane as the tappets. See Figs. 722-772.

Back Spectacle. A small casting containing a roundel at one end and fastened at the other to the semaphore shaft of a signal in such a manner as to change the visible color of the back light, which see, by passing before it. Sometimes instead of carrying a roundel the back spectacle is solid or carries a disk of metal to obscure the back light.

Back Wire. The wire connected to the back tail lever of an interlocking machine to pull a signal to the stop position. Used to ensure that the movements of the signal arm shall follow the movements of the lever. Sometimes, especially in Europe, only one wire (the pulling wire), which see, is used.

Balance Lever. The lever which carries the signal counterweight. See 5, Figs. 1337-1338; 19-19a, Figs. 1521-1524; 26, Figs. 1525-1532; Figs. 1533-1534; 14, Figs. 1560-1563.

Banjo Signal. A common name for the **Enclosed Disk Signal,** which see. So called because in general appearance it resembles a huge banjo.

Banner Signal. A common name for the **Clockwork Signal,** which see.

Basket. A term sometimes applied to a switch adjustment, which see.

Basket Rod. A term sometimes applied to a throw rod, which see.

Battery. A source of electricity. See **Primary Battery; Storage Battery.** See Figs. 2065-2159.

Battery Chute. A small receptacle for batteries. Usually in the form of a hollow cast iron cylinder designed to be set in the ground in order to prevent freezing by keeping the battery below the frost line. See Figs. 2184-2187, 2190-2191, 2197-2200, 2593-2594, 2599-2601.

Bell Code. A code in which are set forth the number of strokes of an electric bell to be sounded to give each of the necessary station-to-station communications in manual block signaling. See **Manual Block System.**

Bell Crank. See **Crank.**

Bell, Electric. A bell actuated by electro-magnets. Used for long-distance communication and to announce trains either at a cabin or a highway crossing. See **Manual Block System, Controlled Manual Block System, Highway Crossing Signal, Telegraph Block System.** See Figs. 571-585, 2046-2049.

Binding Post. A terminal of metal to which a wire may be attached to make an electric connection. The wire is usually clamped in place by a set of nuts screwed to a threaded projection on the post, or is inserted in a hole and held in place by a screw acting at right angles to the hole.

Blade. The wooden portion of the ordinary semaphore signal arm. See Figs, 125, etc.; Figs. 2734-2742.

Blake Signal. An arrangement for electrically controlling by a selective system semaphore signals at a distance, 15 or more signals being controlled by current sent through a single telegraph wire; used on electric railroads. See Figs. 465-470.

Block (noun). A length of track of defined limits, the use of which by trains is governed by block signals. The common name for a block section.

Block Indicator. An electro-magnetic device (in a signal cabin) controlled by a track circuit to indicate to the signal man whether or not that track circuit is occupied by a train. The electro-magnet, actuated directly, or through a relay by the track circuit, has on its armature a miniature semaphore arm, the movements of which give the indications. See Figs. 2019, etc.

Block Section. A section of track of defined length, the use of which by trains is regulated by a fixed signal at the entering end; or, on a single track line, by such signals at both ends. See Figs. 217-227.

Block Signal. A fixed signal at the entrance to a block section used to give indications regulating the movement of trains into that section. If there is a switch immediately in advance of the signal it may be an interlocked signal also. See **Home Signal.**

Block Signaling for Maximum Traffic. The conditions that determine the length of a block section and consequently the number of trains that may be run in a given time are:

1. The speed.
2. The braking power and consequent distance required in which to stop a train running at maximum speed.
3. The grade of the track.
4. The time required for the signals to change from the position indicating "Stop" to that indicating "Proceed."
5. The length of the train.
6. The position of interlocking plants, stations and other local conditions which cause an irregular spacing of the signals.

The number of trains that may be run in a given time is dependent on the speed. The greater the speed the greater the number of trains that may be run. To provide for a maximum train service it must be possible to run trains at the greatest speed local conditions permit, and the blocks must be of such length as to allow this speed to be attained with safety.

To run a train safely at a given speed it is necessary to keep the engineman informed, at all times, of the conditions of the track in front of him and if it is proper for the train to proceed. If it is not safe to proceed the engineman must be warned at a point sufficiently far away from the stopping point to enable him to bring the train to a stop before passing it. The higher the speed the greater the distance from the stopping point the indication to stop or to proceed must be given.

The distant indication is given by the distant signal, and it is therefore necessary that this signal be placed far enough from the home signal to enable a train to be brought to a stop in the distance between the two signals. The braking power then becomes as important an element in determining the length of the block for a maximum train service under safe working conditions as are the factors of speed and grade. With good practice demanding that, as a regular thing, the indication of a home signal shall be repeated by one and not by two distant signals, it follows that for the average conditions the distance between the distant and the home signal is the length of the shortest block that may be used with safety.

The speed of a train is affected by gravity assisting or retarding its motion according to the grade of the track. Any power affecting the speed of the train will have a corresponding effect on the braking power, and the length of the block must therefore be proportioned to the grade.

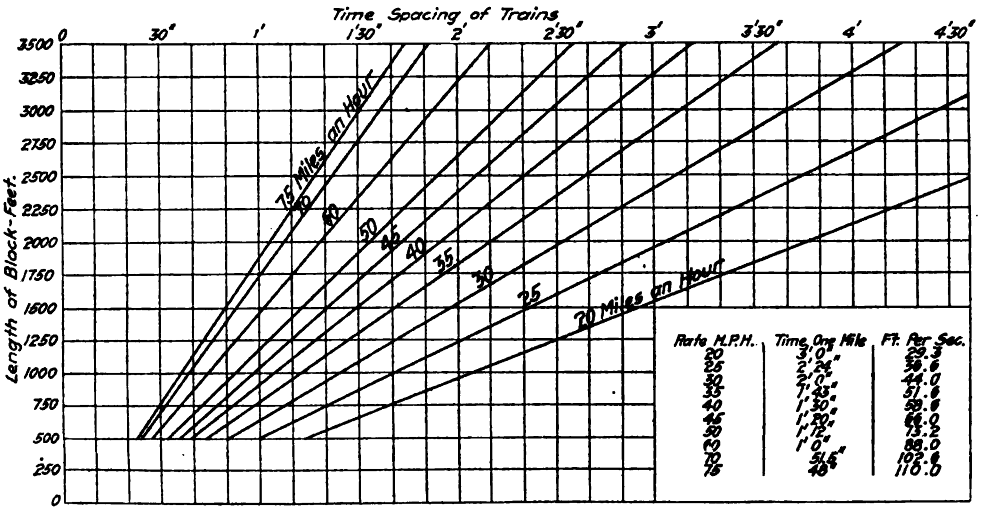
The length of time required for a signal to change from the stop to the proceed position has an important bearing on the efficiency of a signal system and the consequent spacing of trains. The time required for a signal to assume the clear position is

only a few seconds; but, as the home signal does not commence to clear until the train has passed out of the block, the next following train is delayed, while the home and the distant signals are clearing. The practical result is the same as if the block had been lengthened the distance the train will run in the time the two signals are clearing. A maximum train service requires a minimum time for the clearing of the signals. A change from one second to five seconds in the time required to clear a signal—lengthening the time four seconds—will reduce by 10 per cent. the number of trains it is possible to run when the speed is 60 miles an hour and the length of block equal to the braking distance.

The length of a train will affect the number it is possible to run in a given time, for the signals do not commence to clear until the rear of the train has passed out of the block. The train must run its length, in addition to the length of the block, before the signals will clear for the following train. Trains running at speed are spaced the length of the train, plus the length of the block, plus the distance between the distant and the home signals, for with the short blocks necessary for a maximum train movement the application of the brakes at the distant signal, as will be necessary if the signal, when passed, is indicating caution, will reduce the speed so materially that trains will be spaced a greater distance than if they were run far enough apart to get a clear indication at each distant signal.

The position of interlocking plants, stations and similar local conditions, the situation of which is fixed and cannot be changed to permit of the best placing of signals, will affect somewhat the time-spacing of trains. Where the interlocking and station signals occur at such intervals that the blocks are of equal length, the regular spacing of trains can be maintained, but where the blocks are of unequal length trains will be kept further apart and the situation must be carefully studied. At those places where the blocks will be shorter than the required distances between the distant and the home signal the indication of the home signal must be repeated by two distant signals, and the furthest of the two is likely to be found a greater distance from the home signal than the necessary braking distance, thus giving an indication so far away that the train may be stopped some time before reaching the home signal.

Having the information at hand in regard to lay-out of tracks, grades, curvature, station locations, etc., it is necessary before the signals can be located on the plan that an assumption be made as to the maximum speeds which trains will be allowed to attain on the different parts of the line. The accompanying chart shows, in minutes and seconds, at the top of the diagram, the necessary time interval between trains at various speeds, with block signals fixed at different distances apart, as shown at the left of the diagram. The length of a train is assumed to be 520 ft., and provision is made for having at all times *two* home signals in the stop position behind a train. (This is to provide for an overlap, as is done on the New York City subway and the New York Central Electrified Lines.) Therefore, to give each train a clear distant signal, the time intervals between trains must be equal to the time required to run three times the length of one block, plus the length of the train, plus the distance run during the time (assumed to be 4 seconds) required for the home and the distant signals to move from the stop to the clear position, plus a sufficient time for an approaching engineman to see conveniently the distant signal, say 20 seconds. W. H. E.



Block System. "A series of consecutive blocks" (A. R. A.). The method of regulating the movement of railroad trains, so as to maintain an interval of space between trains moving in the same direction (on the same track). It was first used on double-track lines, where a given track is used wholly by trains moving in one direction, but it is equally applicable to single-track lines used by trains moving in both directions. Given a line with stations, A, B, C, D, etc., a train is held (blocked) at A until the last preceding train has arrived at B, and at B until the preceding train has arrived at C, and so on. Thus the normal "space interval" between trains following one another is the distance between stations; but the *minimum* space is the thickness of the signal post, except as modified by the *overlap* (which see) in automatic block signaling and by rigid rules of procedure in manual block signaling. Signalmen are usually required to see that the rear end of a train has passed 300 ft. beyond the home signal (say at B) before giving permission to A to send on another train. This gives 300 ft. leeway as a provision against the danger of a train running past a stop signal and striking the rear of a preceding train which has been stopped immediately after entering a block section. The rules also require that if a train is unexpectedly stopped the rear trainman shall go back

with hand signals to stop any following train. The block system was first used in England, about 1842. It was first used in America on the line between Kensington (Philadelphia), Pa., and Trenton, N. J., about 1863. In 1872, when the Pennsylvania took over this and other lines in New Jersey, the aggregate length of these lines worked by the space interval was 90 miles. The simplest form of the block system is the **Manual Block System,** which see. Other forms are the **Controlled Manual Block System, Electric Train Staff** and **Automatic Block Signal System.**

Bolt Lock. A lock at a switch, consisting of a bolt controlled by the pipe or wire that operates the signal, which is used to permit trains to pass over that switch, so arranged that if the switch is not in proper position the signal connection cannot be moved to clear the signal. See Figs. 1451-1473.

Bolt Lock (verb). To control a switch by means of a bolt lock.

Bond. See **Rail Bond.**

Bond Wire. See **Rail Bond.**

Bonding Plug. A piece of metal, somewhat like a rivet, used to fasten a wire to a rail. See **Channel Pin.** See Figs. 2216-2217, 2220-2222.

Bonding Tube. A tapered iron or steel tube, coated with tin or copper, and having a longitudinal slit for fastening a bond wire to a rail. It is of the same general size and is used for the same purpose as a channel pin. See **Channel Pin.** See Figs. 2214-2215, 2223-2225.

Bootleg. In track-circuit connections, a short piece of wooden trunking enclosing the wire leading from the rail down to the horizontal part of the wire (sometimes not enclosed in trunking) leading to the battery box or the relay box. The term is also sometimes used to include the wire itself. See Figs. 3033-3035, 3037-3052, 3057-3062.

Box Crank. Two or more cranks assembled in a common frame, each crank having an independent bearing. See Figs. 1442-1450.

Boxing. Wooden covering for pipe or wire lines. Used to exclude dirt or to prevent persons from stepping on the pipe or wire; also used to enclose pipe or wire lines when laid beneath streets.

Box Wheel. A group of chain wheels mounted in one frame. See Figs. 1417-1432.

Bracket Post. An arrangement for supporting two or more signals, side by side, on a single foundation. See Figs. 1529-1532; 20-49, Figs. 2613-2661; Fig. 2663.

Bridge Circuit Controller. A device for connecting and disconnecting circuits at a drawbridge actuated by the same lever that moves the bridge lock or uncouples the pipe lines, or by a separate lever when the bridge is set in position (and locked), or when it is unlocked. See Figs. 2307-2317.

Bridge Coupler. The coupling at the end of a drawbridge in a pipe line, which extends from a cabin on the drawbridge to a function not on the drawbridge, or vice versa, designed to be quickly disengaged when the bridge is to be opened and quickly engaged, when the bridge is again closed. See Figs. 1586-1588, 1603-1605.

Bridge Lock. A device for locking a drawbridge in its closed position, so interlocked with the signals approaching the bridge that they cannot be cleared unless the bridge is in proper position. See Figs. 1580-1585, 1589-1602.

Bridle Rod. See **Front Rod.**

Buffer. See **Dash Pot.**

Bus Bar. On a switchboard or other terminal, a common conductor, usually a rectangular copper bar, from which taps may be made for connecting up recording instruments, such as ammeters, wattmeters, etc., or for taking off current for local circuits.

Butting Collision. A collision between meeting trains —trains moving toward each other on the same track.

Butt End. A term applied to a jaw or bar whose end is cut off without tang or thread. See Figs. 1014-1016, 1023-1098.

Butt Strap. An iron block, riveted to a tie plate, which see, to take the side thrust of the rail through a rail brace, which see.

C

C. M. Abbreviation for Circular Mill.

Cab Signal. A signal in the cab of a locomotive. The term is used to include all arrangements for producing visual or audible indications on moving engines or cars by means of mechanical, electrical or magnetic devices situated on, or at the side of or above the roadway, and producing effects on moving vehicles. Such devices have not come into general use and have been tried on but few railroads. See **Automatic Stop.**

Cabin. A common name for the building from which signals are operated. Usually two stories high, with the signalman's room in the second story; often called a tower. Some interlocking cabins, containing machines of many levers, are from 50 ft. to 100 ft. long. See Figs. 2970-3005.

Cable, Electric. An electrical conducting wire, or, more commonly, a collection of such wires, embedded in an insulating covering. Cables are used to conduct electric currents beneath rivers, as at drawbridges; for connections from poles to offices or cabins, or in any situation where a multiplicity of separate wires is objectionable, or where the conductors must be protected from gases, or other injurious substances, and in electric interlocking for connections from cabins to switches and signals, usually under ground. See Figs. 3075-3080.

Cable Tracer. One of the wires in a cable marked in such a manner as to be readily distinguishable from the other wires and used in tracing circuits through the cable.

Calling-On Arm. A semaphore signal arm used to authorize a train to move (toward the signal cabin), past a home signal when the principal arm of the signal has to be left at "stop" because the block section is not clear or because for any reason it would not be allowable to permit the train to pass the signal unconditionally. The calling-on arm is usually smaller than the standard semaphore arm, and is placed below the standard size arm or arms. In England the calling-on arm is common, but in America it has found little or no favor except on the Pennsylvania, where recently the term has been applied to the dwarf-size arms, which are used on full-size posts (or on bridges) in the scheme for "speed signaling" which has been intro-

duced in connection with three-position signals for interlocking, and which is illustrated in Figs. 165-176. In this scheme the small lower arm is inclined to the 45-deg. position to give the "calling-on" indication. Besides this indication that speed is to be controlled, the function of the arm is limited by the rules, which say that it is to be used only for low speed routes. Being thus limited, the calling-on arm can be used, for example, to move a train (or part of a train) past a home signal, forward, on the main line, to be coupled to the rear of a train which is stopped a short distance in advance.

Cage. A term sometimes applied to a switch adjustment, which see.

Cage Rod. A term sometimes applied to a throw rod, which see.

Capping. Covering for trunking, which see.

Cantilever Bracket Post. A substitute for a bracket post. See Figs. 2613-2642, in which the cantilever signal 14 is a substitute for and conveys the same information as the bracket signal 21; likewise 18 may be substituted for 27. See **Bracket Post.**

Caution Card.—In block signaling a written order issued by a signalman to authorize a train to enter a block which is not clear. See **Permissive Block Signaling.** Form B, of the Standard Code of the American Railway Association, is shown, reduced in size, below:

................(NAME)................ COMPANY.

CAUTION CARD.

Block Station............, ...M., ...190

To Engineman, train No............on............track.

Block is not clear. You may proceed with caution expecting to find track obstructed.

....*Signalman.*

Enginemen receiving this card properly filled out and signed by the signalman, may proceed with the train under control prepared to stop short of any obstruction in the block.

[PRINT NAME.]
....*Superintendent.*

Another form (Form D) is used when the communicating wire from station to station is broken or otherwise unavailable.

Caution Signal. A signal indication denoting that a train may proceed under some restriction usually (in permissive block signaling) with the understanding that a preceding train moving in the same direction may be overtaken at *any point* in the block section, and that therefore the speed must be very low, except as the engineman is able to see a clear track for a considerable distance ahead. Thus, on a long, straight track, in clear weather, "cautionary" speed is not necessarily low speed. "Caution" is used, but with a different meaning, as the name of the indication of a distant signal which says "proceed," expecting to find the next home signal indicating *stop.* As the home signal referred to may be a mile or more away the distant signal does not require speed to be reduced or limited at any specific point, the reduction or limitation must be applied wherever it may be necessary in order to insure a stop at the home signal. If, when the home signal is seen it proves to have been put in the clear position, the "caution" indication at once becomes void.

Cell. One unit of an electric battery.

Chain Wheel. A grooved wheel about 10 in. in diameter, mounted in vertical or horizontal bearings, about which ¼-in. chain is passed to change the direction of a signal wire line. For a short distance a chain is used in place of the wire and the chain is guided by the groove in the rim of the wheel. See Figs. 1339-1398, 1417-1432.

Chain Wheel Stand. A casting carrying one or more chain wheels. A one-way chain wheel stand carries one wheel; a two-way stand carries two wheels.

Channel Pin. A device used to fasten a wire to a rail; a truncated cone, in which is cut a longitudinal slot of radius equal to that of the wire. The pin is inserted in a hole in the rail with the wire and driven home, thereby wedging the wire firmly in place. See Figs. 2206-2210, 2218-2219.

Check Lock Lever. In an interlocking machine, a separate lever which is used for **Check Locking,** which see. Also called traffic lever. See Fig. 2017.

Check Locking. A method of interlocking electrically the levers in two adjacent interlocking plants to permit train movements to be made against the current of traffic. In electric and electro-pneumatic interlocking plants there is usually provided in each tower a separate lever for each track over which reverse movements are to be made. These levers are connected with the mechanical locking in such a way that, when they are in their normal position, the signal for reverse movements is locked in the stop position and the signal for movements with the current of traffic is free to be moved. When both check lock levers are reversed the signal (for normal movements) is mechanically locked in the stop position and the dwarf signal (for reverse movements) at the adjacent interlocking is unlocked to allow reverse movements. See Figs. 2017-2018.

Chute. See **Battery Chute.**

Circuit Breaker. A switch, controlling an electric circuit, which normally is closed. See Figs. 2226-2317.

Circuit Closer. A switch, controlling an electric circuit, which normally is open. See Figs. 2226-2317.

Circuit Controller. A switch, push-button, plug, or any similar means for conveniently opening and closing an electric circuit. See Figs. 2226-2317.

Circuit, Electric. See **Electric Circuit.**

Circular Mil. A unit of area employed in measuring the cross-sectional area of wires, equal to .7854 sq. mil. The area of a circle 1 mil., or .001 in. in diameter. One circular mil. equals .000000785 sq. in. The area of cross-section of a wire in circular mils. is equal to the square of its diameter in mils.

Clear (verb). To put a signal in the position or aspect to indicate that a train may proceed.

Clear Signal. A common term to denote the indication of a signal in the "proceed" position. It may refer to a home signal indicating proceed at unlimited speed; or to such a signal indicating proceed at limited speed (over a diverging track); or to a distant signal indicating proceed, expecting to find the next signal clear. In Great Britain "all-clear" is used in the same sense.

Clearance Card. In block signaling a written order issued by a signalman to authorize a train to enter a block when the signal cannot be cleared. Form C of the Standard Code of the American Railway Association is shown, reduced in size, below:

(NAME) COMPANY.

CLEARANCE CARD.

................Block Station, ..., 190 , ...M.

To Engineman

Train No............on.................track. Signal cannot be cleared; proceed.

...., *Signalman.*

This card must be used only in case of failure of block signal apparatus, and when block has been duly reported clear by the signalman at the block station in advance. The engineman receiving it duly dated, timed, and signed, may proceed.

(PRINT NAME.)
....*Superintendent.*

Clearance Point. At a convergence of two tracks that point beyond which the widest cars or engines, running in the converging direction, cannot run without a possibility of fouling vehicles on the other track.

Clockwork Signal. One of the early forms of automatic block signal mechanism; still in use in New England. It is a disk signal revolving on a vertical spindle. When the disk or target is visible to the engineman it indicates stop, and when turned with the edge toward an approaching train (disk not visible) it indicates clear. A common form has a second target of different shape mounted on the spindle at right angles to the stop target which serves for the clear indication. The stop target is usually painted red, and the proceed target, when used, is painted white or green. See **Night Signal Indication.** The spindle is rotated through a chain of gears similar to the works of a clock, by a weight suspended inside of the iron signal post. A detent operated by a magnet controlled by the track circuits prevents the disk from revolving more than one-quarter of a revolution for each operation of the signal. See Figs. 399-400.

Closed Switch. A switch (in a railroad track) which is set for the normal current of traffic; an outlying or siding switch, set for the main track.

Coleman Lock and Block Instrument. An improved form of the Sykes lock and block instrument for a controlled manual block system, devised by J. P. Coleman. See Figs. 251-272.

Colors of Signals. A semaphore arm gives its indication by form and position, independent of its color, but for convenience the blades (the wooden portion of the arm) are usually painted red for home signals and yellow or green for the distant signals. A white transverse stripe is common (see Figs. 125-128). On a few roads all signal arms are painted one color (yellow). The back sides of blades are painted white or a neutral color. In enclosed disk signals the disk is red for home (stop) signal, and for the distant it is green or yellow, according to the colors used in the light at night. The efficiency of an enclosed disk signal depends on the contrast between the appearance of the disk and that of the surrounding surface of the case. When the signal is cleared (the disk withdrawn from sight) the inner surface of the back of the case (white) constitutes the clear signal. See **Night Signal Colors.**

Common Wire. A wire used jointly or "in common" by two or more electric circuits, through part of the route of each. When two or more circuits are supplied with current from one source, as a battery, the main leads from the battery are "common" to all such circuits.

In early signal practice it was customary to economize in the use of wire by making the ground a "common" return conductor for nearly all circuits in the same manner as is still done in the telegraph. But on account of difficulty in maintaining good ground connections this practice has been discontinued to a large extent, the "common" return wire being substituted.

NOTE.—This practice, although at present in general use, has certain undesirable features. Its use results in complications in circuits, and occasionally trouble is caused by the common wire being overloaded, resulting in a drop in potential between different points. Again, if the common wire, as, for instance, at a power interlocking plant, becomes disconnected or broken it is likely to interfere with the operation of the entire plant, and also under certain conditions is liable to cause functions to operate improperly. Foreign currents also are sometimes collected or distributed by the common wire, especially where it extends several miles, as in automatic block signaling, and to limit the effects of such disturbing elements it is the practice on some roads to limit the length of common wires to a few miles.

Compensator. A device for increasing and decreasing the length of long lines of pipe or wire to adjust them to changes in the temperature of the atmosphere, so as to keep the length of the pipe or wire constant. In pipe lines this is accomplished, where the direction of the line is changed, by different arrangements of cranks, and in straight lines by a "Lazy Jack." For wire lines various automatic compensators have been tried and have been rejected as unsatisfactory. See **Pipe Compensator; Wire Compensator.** See Figs. 1107-1108, 1111-1162, 1282-1284, 1333-1338, 1606-1609, 1614.

Conductivity. The capacity of a substance, as a wire, for conveying electric current; the reciprocal of electric **Resistance,** which see.

Conduit. A tube of wood, clay, iron or fiber, enclosing electric wires, usually under ground.

Contact Finger. See **Front Contact** and **Back Contact.**

Controlled Manual Block System. The manual block system safeguarded by the addition of electric locks, attached to the signal levers and controlled from the adjoining block stations, so arranged that a clear signal cannot be displayed to admit a train into a block without the simultaneous action and consent of the signalmen at both ends of the block. The controlled manual system was developed in England by W. R. Sykes, where it is known as "Lock and Block." In 1882 a few Sykes instruments were installed on the New York Central in and near New York City. Coleman's controlled manual instrument is an improved form of the Sykes instrument, devised by J. P. Coleman, and the few original Sykes instruments installed in the United States have been replaced by it. Track circuit control (at each station) is an important element of the system, but in some cases it is not used. By the addition of a complete track circuit throughout the length of the block sections the controlled manual system can be made to more surely provide against a collision due

to the accidental breaking of a train. If, by accident or otherwise, the rear car of a train should be detached and left in a section, while the rest of the train passed out of it, and if in such a case the signalman at the outgoing end should carelessly assume that the whole of the train had passed him, it would be possible for him to empower the station at the entering end to send forward a second train. The continuous track circuit prevents this, as in automatic block signaling. See **Electric Train Staff.**

Copper-Clad Wire. An electrical conductor made with a steel center, surrounded by copper. For lines strung on poles, by the use of copper and steel in the right proportions, copper for conductivity and steel for mechanical strength, wire of a given conductivity can be made at a cost less than that for either copper wire or steel wire. The welding of the steel and the copper is done by the "Monnot" process.

Counterweight. In a semaphore, a weight so connected that, in case of breakage of the wire or the pipe controlling the signal, the weight will fall and pull the signal to the horizontal (stop) position. Any failure of a signal should result in an indication adverse to the movement of trains, thus tending to safety and to the discovery and repair of the defect which has caused the failure. Semaphores, in which the arm is inclined upward for the proceed indication, need no counterweight. See Figs. 1337-1338, 1498-1500, 1521-1532, 1549.

C. R. Abbreviation for Cold Rolled. Used in connection with steel and iron.

Crane. See **Staff Crane.**

Crank. In interlocking work, a lever used to change the alinement or direction of travel of a pipe. Cranks are straight when the arms make an angle of 180 deg. with each other. See **Equalizer** and **Straight Arm Compensator.** "T" cranks have three arms and are shaped like the letter T. When the arms are at 90 deg. to each other the term "crank" is used alone. See Figs. 1017-1022, 1099-1135, 1149-1162.

Crank Stand. The frame in which cranks (in a pipe line) are supported. See **Crank.**

Cross Arm. An arm, usually of wood, fastened to a telegraph pole, near the top, at right angles to the pole; designed to carry the pins and insulators to which line wires are attached. See Figs. 2430-2436, 2443-2447, 2459.

Cross (of wires). The accidental contact of electrical conducting wires. In signaling, such an accident, by increasing the current in a wire or reversing its polarity, or by energizing a wire which should be dead, may produce derangements of apparatus. Circuits controlling signals should always be so arranged that either a cross or a break will cause the signal to indicate stop, or if already thus indicating to remain so until the fault is corrected.

Crossing Bar. A detector bar used near a crossing and operated by a separate lever in an interlocking machine. By its use a train on the crossing is protected against the wrongful clearing of signals for trains on conflicting routes. See **Fouling Bar.** See Figs. 622-625.

Crossover. A short track leading from one to the other of two parallel tracks. See Figs. 353-354, 358-363, 628-629, 632-635, 638-643, 652-656, 658, 951-954.

Cross Locking. In Saxby & Farmer interlocking, the transverse bar which is moved by the locking dog. See 26, Fig. 665.

Crowfoot Zinc. A form of zinc plate used in a **Gravity Cell,** with a vertical stem and several radiating spokes or toes, resembling the foot of a bird.

Current, Electric. See **Electric Circuit** and **Ohm's Law.**

Current of Traffic. On a double-track railroad the normal movement of trains in a given direction, as for example, eastward on the south track, and westward on the north. To move westward on the south track or eastward on the north track, in that case, is "against the current of traffic."

Current Wave. The increase from zero to maximum and the decrease from maximum to zero of the value of an alternating current.

Cut Section. In automatic block signaling, a familiar term used in cases where a block section is too long to maintain a single track circuit (by reason of the imperfect insulation of the rails). The block section is divided at the middle—or in extreme cases is divided into three parts—and is called a "cut section." A section which does not reach to the signal may repeat into the adjacent section by a relay, or it may be made to control the home signal directly by a line wire. See Figs. 337-339, 346-347, 372-373, 375-376, 379, 382, 384-385, 387, 393, 395.

Cycle. In an alternating current a complete change in direction from maximum negative through zero to maximum position and back to maximum negative. The frequency is expressed as the number of cycles per second.

D

Danger. A term formerly used to denote the "stop" indication of a signal; still used in the combined term "normal danger," meaning an automatic block signal system, in which the signals indicate stop (or, in the case of a distant signal, caution) at all times except when a train is approaching.

Dash Pot. A cylinder with a piston, designed to act as an air cushion for a falling weight, the piston being attached to a rod supporting the weight. See 6, Figs. 408-409, 412-413; 8, Fig. 421; N, Fig. 440; 4, Fig. 446.

Deflecting Bar. A device for changing the direction of a line of pipe. See Figs. 1165-1184.

Deflecting Bar Leadout. See Figs. 1494-1496.

Deflecting Stand. See Figs. 1165-1184.

Derail (noun). A short name for **Derailing Switch,** which see; also for a "scotch block" or any device in a fixed location, for throwing cars and engines off the track. See Figs. 612-616, 622-629, 632-633, 636-639, 642-643, 656-658, 1505-1520.

Derailing Switch. A switch designed to turn a train off the track for the purpose of preventing it from running into danger; used in connection with stop signals on lines approaching grade crossings of other railroads, or drawbridges, or any particularly dangerous place. It may be interlocked with a stop signal so that when the derail is "open," to derail, the signal must indicate stop; and before the signal can be cleared the derailing switch must be set so as *not* to derail an approaching train. See Figs. 612-616, 622-629, 632-633, 636-639, 642-643, 656-658. A diverging track, if not too sharply curved, serves the same purpose without causing derailment. Derailing switches worked by hand (sometimes not interlocked with the switch) are used near the ends of outlying side tracks, especially where a movement from the siding to the main line has the

benefit of a descending grade. Such a derailing switch is regularly left open, so as to derail any cars which may by accident run from the siding toward the main line when no attendant is near.

Detector Bar. A device for preventing the movement of switches under trains. A long, thin strip of metal is mounted on pivoted links alongside of the track rail, on its outer side, in such a way that when moved longitudinally the bar is lifted higher than the top of the rail. The bar is so connected to the switch movement, with which it is used, that it must be lifted before the switch is moved. It is located either in advance or in rear of the switch, and sometimes both. If any pair of wheels is on the rail along which it is mounted the bar is prevented from moving by coming in contact with the wheel tread which projects over the edge of the rail. If the detector bar cannot move, the switch cannot be moved, and the arrangement therefore prevents throwing a switch under a car. Detector bars are used with both mechanical and power-operated switches. They derive the name "detector bar" from the fact that the signalman in a mechanical interlocking could detect by the pull on the lever whether the detector bar were blocked. In power interlocking they are now being replaced in many installations with electric track circuits controlling electric locks on the switch levers. See **Detector Bar, Inside;** also **Electric Detection; Detector Track Circuit, Detector Locking.** See Figs. 910-917, 919, 950-1007.

Detector Bar (Inside). An arrangement for preventing the movement of a switch while it is occupied by a car. The common **Detector Bar,** which see, keeps the switch locked by the pressure of the outer part of the treads of the wheels of the car. The inside bar is controlled by the flanges of the wheels. The older form of inside bar was arranged to normally lie flat, and in moving was turned upward by the movement of a long rod lying parallel to the bar and fixed to it, the rod being turned on its axis. A later form is worked in about the same way as the outside bar. The effectiveness of the outside bar depends on having car wheels with treads wide enough always to extend a good distance outside of the head of the rail. With wide-headed rails this is an uncertain factor.

Note on Detector Bars.—Inside detector bars are objectionable because, by reason of the presence of switch rods and other track accessories, it is impossible in many situations to put the bars where they are needed, and also because wheel flanges are not of uniform depth. For this and other reasons the outside bar is more generally used. But the introduction of rails with very wide heads has lessened the effectiveness of outside bars; because with the width of the wheel treads only a little greater than the width of the rail head the bar may not be properly held down. This has led to the introduction of "electric detection" for this purpose.

Detector Bar Driving Piece. A stud and plate, or eye, bolted to a detector bar, on which is attached the driving rod connected with the switch movement with which the detector bar is used. See Figs. 969-971.

Detector Bar Link. A short link supporting a detector bar, and so pivoted on a clip fastened to the rail that the detector bar in moving longitudinally must also move upward and above the top of the rail. See Figs. 955-956, 974-1002.

Detector Bar Stop. A lug bolted to the rail on which the detector bar rests when the stroke is completed. See Figs. 957-973.

Detector Locking. See **Electric Detection.**

Detector Track Circuit. A track circuit used in connection with electric detection, which see. So called because used to perform the same function as a detector bar.

Diagram, Track. See **Track Indicator, Track Model.**

Diaphragm Valve. A valve, controlling the admission of compressed air from an operating pipe to a switch or signal cylinder, which is itself worked by compressed air in another pipe—the control pipe. The pressure in the control pipe, increased or diminished by the signalman in the cabin, moves a flexible leather diaphragm up or down and thereby actuates the valve stem. See **Pneumatic Interlocking,** Figs. 1966, 1969, 1970.

Differential Relay. A relay, the coils of which have two or more different windings; or a relay having two or more magnets acting in certain relation to each other. See Figs. 380, 390, 392-394, 396-398, 2571-2573.

Direct Current. A current of electricity constant in direction as distinguished from an **Alternating Current,** which see. A continuous current. The current derived from all primary and storage batteries is direct current.

Disengaging Lever. A lever hung by shackles from the balance lever of a signal when the signal is wire connected. The pulling and back wires, which see, are hooked to the disengaging lever in such a manner that should the back wire break the disengaging lever would be released and fall to the ground, thereby disconnecting the signal from its operating mechanism and allowing it to go to the stop position. See Figs. 1337-1338.

Disk Signal. A signal in which the day indications are given by the color or position of a circular disk. The term is commonly restricted to an **Enclosed** Disk Signal, which see. A **Clockwork Signal,** which see, is a disk signal in which the day indications are given by the position of the disk as it is turned to one or another of two positions by the revolution on its axis of a vertical spindle. See Figs. 400-407.

Distant Signal. A fixed signal situated 1,500 ft. to 3,000 ft. or more in the rear of a home signal to indicate to a train whether or not the home signal may be expected to be found in the clear position. It is distinguished from home signals by a notch in the end of the blade. Finding the distant signal in the "clear" position, trains may proceed at unchecked speed, while if it shows "caution" it is a warning that the train must be prepared to stop at the home signal. On a line where, by reason of curves and intervening buildings, hills or trees, the home signal cannot be seen by the approaching engineman until he is quite near it; or on any line, curved or straight, when the engineman's view is obscured by fog or by falling snow, distant signals are necessary in order to avoid delay to fast trains, as without this preliminary information the speed of such trains would have to be materially slackened in order to enable the engineman to be sure of the reading of the home signal before he passed it. A mechanical distant signal is so interlocked that it can never be cleared until the home signal is cleared, and if there are other signals for that route at that station on that track the distant is so interlocked that all of them must be cleared before

it can be cleared. A distant signal may be fixed on the same post with the home signal for the next section in the rear, and in that case it is arranged to be controlled by the latter in such a way that whenever the home goes to stop the distant will go to caution, even if its own home signal (a block in advance) does not require it to do so. This is done to avoid giving to enginemen what might seem to be two inconsistent indications at the same point. In the automatic block signal system the distant signal is controlled by the home signal, and is usually mounted on the same post with the first home signal in the rear. In a system of **Three-Position Automatic Block Signals,** which see, each signal gives a distant indication for the next signal in advance. The various forms and indications of distant signals are shown in Figs. 126, 131-135, 152-153, 157-159, 164, 206, 219-227. See **Home Signal.**

Distant Switch Signal. A signal, arranged like a mechanical distant signal, but used only to indicate the position of an outlying switch. Its lever is usually interlocked with the lever of the switch. Distant switch signals (for trains running in the "facing" direction) were used considerably before block signals were common; but when the block system and interlocking are introduced the switch signal usually is either removed or is made a part of the new system.

D. C. Abbreviation for Direct Current.

Dog Chart. A diagrammatic representation of the mechanical locking for an interlocking machine; used as a working plan in making up and fitting the locking. See Figs. 612-881.

Dog Locking. See **Locking.**

Doll. A word, of doubtful origin, sometimes used to designate a short signal post, as the upper posts of a bracket-post signal.

Double Jaw. See Figs. 1023-1098.

Dummy. Literally, a counterfeit; used to designate a "doll" or short signal post, on a bracket-post signal, bearing no signal arm and designed merely to aid, by its position relative to the other "dolls" in showing to which of two or more tracks a signal applies. A dummy may carry a light of distinctive color to fulfil its function at night.

Duplex Lock. A lock for a switch with two plungers, one of which locks the switch in its normal position and the other in the reversed position. It is so arranged that both cannot enter the same hole in the lock rod. See F, Figs. 898-909.

Dwarf Interlocking Machine. A small interlocking machine often set out of doors. In a common form of two-lever machine one lever works the switch and the other a distant switch signal. See Figs. 877-881. Except in this case these machines are used only on low-speed tracks, as in freight yards, and the locking is lever-locking (not "preliminary"). See Figs. 1610-1612, 1623-1640.

Dwarf Semaphore Signal. Commonly abbreviated to "dwarf." A low semaphore signal used for giving indications for low-speed movements, as through an interlocking plant in the reverse direction to the normal current of traffic or on or from a side track. Dwarf semaphore signals are used also to give indications in the normal direction, as in the case of movements from a main track to a side track in the normal direction, the dwarf being set close to the high signal post. Dwarfs are frequently used at terminals for movements in the normal direction. See Figs. 1554-1556, 1560-1567, 1572-1577. The arm of a dwarf is about 3 in. wide and 9 in. long, and is usually about 2 ft. above the level of the rail. It is often made of rubber or thin sheet metal to prevent damage in case of fouling with cars or locomotives. The day indications of dwarf arms are the same as for full-size semaphore arms, as shown in Figs. 125-176. For the night indications by color, see **Night Signal Indications.** Figs. 177-216, show usual arrangements of dwarf and high signals with the routes which they control.

Dynamo. A common term for electric **Generator,** which see.

E

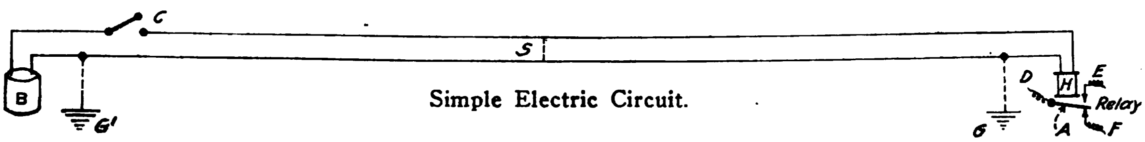
E. M. F. Abbreviation for Electromotive Force.

Eddy Currents. Induced currents produced in the armature core of a dynamo or any small closed circuit in the presence of a changing magnetic field. See **Induced Currents.** See Figs. 530-534.

Electrical Bridge Coupler. See **Bridge Circuit Closer.**

Electric Bell. See **Bell, Electric.**

Electric Circuit. The accompanying diagram shows a simple electric circuit. It consists of a source of energy, in this case a cell of battery, B, a device for making and breaking a contact, called a circuit controller, C, corresponding to the key in a telegraph circuit, and two wires leading to the apparatus (in this case a relay) to be operated. The relay consists of an electro-magnet, H, and its soft iron armature, A, mounted on a lever pivoted at one end and free to move between two stops at the other. The armature is held away from the magnet by gravity or by a retractile spring.



Simple Electric Circuit.

The circuit controller being "closed" so as to make contact, current will flow from one side of B, through C, along the upper wire, through the coils of H, back along the lower wire to the other side of B. The earth is an electrical conductor, or rather a reservoir of electricity, so that the lower wire may be omitted and the current return through the earth, by putting in ground connections as at G and G'. In signal work this practice cannot always be followed to advantage on account of difficulty in maintaining good ground connections, and also on account of the interference of current from other circuits which are also using ground returns.

The current passing through the turns of wire around the soft iron core of the electro-magnet, H, causes it to become magnetized to an extent approximately proportional to the amount of current flowing; therefore, if the current produced by the battery is strong enough, the magnetism in the core will overcome the weight of the armature and lever to which it is attached, drawing the free end away from the lower or back contact, F, and against the upper or front contact, E. The relay is now said to be "energized," and its armature

will remain in this position until the current is cut off by opening the circuit controller, or by breaking or otherwise disconnecting the wire, or until the amount of current passing through the coil (and consequently the force of the magnetism of the core) is reduced so much that its attraction is overcome by the weight of the armature, which pulls it back to its original position. The current passing through the relay may be reduced by weakening the battery, or by a "shunt" or "short circuit." Suppose that the circuit controller is closed and the relay energized, as already explained; if now the two wires are connected by a third piece of wire, as shown dotted at S, there are then two paths provided for the current. In such cases the current flowing in each is inversely proportional to its resistance. For example, if the resistance of H is 5 ohms and that of S, 1 ohm, with an output of 600 mil-amperes from the battery, 100 mil-amperes will pass through H and 500 through S. By making the resistance of the shunt, S, very low, compared with that of H, practically all the current may be made to pass through S, and thus the relay may be de-energized while the battery is still connected and giving current. This is what takes place in track circuit signaling, the wheels and axles providing the shunt connection.

As regards the "polarity" or direction of the current through the circuit, the results described will be the same if the positive pole of the battery is connected to the wire leading to C, and the negative pole to H, or vice versa.

Electric Detection. The use of track circuits and relays for controlling electric locks on the switch or signal levers of an interlocking machine, or opening the controlling circuits of switches to prevent switches from being thrown under cars, a function originally performed by a detector bar, which see. Electric detection, however, is usually extended to the fouling points of the switch controlled, and may be used instead of or in addition to detector bars. See Figs. 1995-2016.

Electric Interlocking. Interlocking apparatus, in which the switches and signals are worked by electric motors or electro-magnets. See Figs. 1641-1896.

Electric Lock. See **Lock, Electric.**

Electric Locking. See **Locking Electric.**

Electric Motor. See **Motor, Electric.**

Electric Railroad. By years of usage this term has come to mean, generally, a railroad of the nature of street railroads such as were formerly operated by horse power; but electric power is used under such varied conditions that the term is not definitive. Street railroads extending many miles, from town to town, are called interurban. These and all electric lines operated by power drawn from a power house through an overhead wire by a wheel contact are called trolley roads. On many electric lines in the streets of large cities, power is taken from a conductor laid in a conduit beneath the surface of the street. On elevated and underground city railroads and on the New York Central & Hudson River and the Long Island railroads power is taken from a third rail. These last-named lines were formerly worked by steam locomotives, and these are still used on them when desirable or necessary. On a few interurban lines and on certain lines of the Erie and the New York, New Haven & Hartford railroads power at high tension for heavy trains is taken from overhead conduits by sliding contacts. On the great majority of interurban roads the signaling is incomplete or entirely lacking, the moderate speeds and the absence of large terminals and junctions being held to warrant dependence on more primitive and less costly methods. As speeds are increased standard signals and signaling methods are found necessary.

Electric Selector. A group of circuit controllers actuated by the points of a switch and used to determine which arm of a signal or which signal of a group shall be free to be cleared when the switch is moved to a given position. See Figs. 1751, 1765-1769, 2226-2252, 2255.

Electric Slot. A device in which the connection between a signal arm and its operating mechanism is controlled by an electro-magnet, the connection being broken when the magnet is de-energized and established when the parts are in proper mechanical relation and the magnet energized. Commonly used to prevent the clearing of a signal, or to cause it to assume the stop position when the route or track section, the use of which by trains is governed by the signal, is obstructed. See Figs. 2814-2829.

Electric Switch Lock. An electric lock controlled from a signal cabin and attached to the operating connection of an outlying switch to prevent the switch from being moved without the knowledge and consent of the signalman in the cabin. A telephone or a key and bell are usually added in the mechanism case to provide a means of communication between the switch and the cabin. With a telephone attachment a condenser is sometimes employed and the bell circuit or switch lock control circuit is used for the telephone circuit. See Figs. 1991, 2866-2881.

Electric Train Staff System. A method of regulating the movements of trains on a single-track railroad. See Figs. 291-325.

Electro-gas Signal. A semaphore signal worked by compressed carbonic acid gas. See Figs. 447-453.

Electrolysis. Chemical decomposition effected by means of an electric current—Houston. The opposite of the electro-chemical action which takes place when current is generated in a voltaic cell. The action of the plates and electrolyte in charging a storage battery is electrolysis. The stable chemical elements and compounds of pure lead, lead oxide and sulphuric acid are dissociated by the passage of the charging current through the battery and combine to form unstable chemical compounds which do not become active, however, until the external circuit is closed. When the battery is discharging exactly the opposite chemical reactions take place, the unstable compounds rearranging themselves to form the original stable compounds and this chemical change is accompanied by the generation of an electric current. Electrolysis manifests itself in the form of corrosion of pipes, wires, etc., buried under ground or exposed in damp places to the effects of stray electric currents. The moisture in the air combined with carbonic acid or in damp ground with earthy salts forms the electrolyte, which is necessary for the electrolytic action to take place. The pitting or corrosion of pipes appears at the point where current leaves the metal through the earth. It may occur even with currents of very low voltage.

Electrolyte. The liquid surrounding the plates or elements of an electric cell, containing in solution the chemicals which act on the elements to produce an electro-chemical current. The electrolyte is the

conductor of the current within the cell between the plates. It is usually a dilute acid or a solution of acid derivative salts in water, or a strong alkaline solution.

Electro-Magnet. The magnet produced by the passage of an electric current through a coil of insulated wire surrounding a core of magnetizable material. In common practice, electro-magnets consist of a coil or coils of insulated wire, wound about a soft iron core. See **Magnet.**

Electro-Mechanical Slot. See **Electric Slot.**

Electro-Pneumatic Interlocking. Interlocking apparatus in which the switches and signals are worked by compressed air, but the valves which control them are operated electrically from the cabin. See Figs. 1897-1965.

Electro-Pneumatic Signals. Semaphore signals worked by compressed air and controlled by electric apparatus. In electro-pneumatic interlocking the electric control is managed by the signalman in the cabin; in electro-pneumatic block signaling the air-valves at the signals are controlled by the track circuit. See Figs. 454-464, 535-538, 540-541.

Elevator. In a battery chute, the movable frame supporting the jar or jars, and its rope, arranged for conveniently raising the battery for inspection. See Figs. 2190-2191, 2198-2200.

Enclosed Disk Signal. The simplest and earliest form of automatic block signal, introduced in 1871, and still in wide use. The signal indications are given by color, both day and night. A circular disk of light cloth or thin metal, colored red or green, enclosed in a weather-proof case, with a glass front, is displayed for the day indication of stop or caution and withdrawn from sight for the proceed indication. See Figs. 401-407, 2689-2697, 2703-2704.

End Post. See **Insulated Rail Joint.**

Escapement Crank. A crank, used in a "switch and lock movement," by means of which a single stroke of a lever performs three operations: First moves the detector bar and unlocks the switch; second moves the switch; third moves the detector bar back and locks the switch. See Figs. 882-889.

Equalizer. See **Straight Arm Compensator.** See Figs. 1107-1108, 1111-1135; D, E, F, Figs. 1149-1162.

F

F. P. Abbreviation for Facing Point.

F. P. L. Abbreviation for Facing Point Lock.

Facing Point Lock. A lock for an interlocked switch, worked or controlled by the signalman, so called because used chiefly at facing point switches and seldom or never at trailing point switches. In and near large terminals all switches are provided with locks, all being frequently traversed by trains in both directions. The operating connection of a switch ordinarily holds it in position; the lock is an additional provision for insuring accuracy of movement. At a trailing point switch extreme accuracy is not essential. See Figs. 910-917, 919.

Facing Point Switch. A switch so situated, as related to an approaching train, that the pointed ends of the switch rails point toward the train. To a train coming from the opposite direction the same switch would be "trailing." In British practice the word "points" (the two pointed switch rails) has the same meaning as the American term "switch," and the English say simply "facing point." At a facing point switch a train takes either one or the other of two routes. At a trailing point, if the switch is not in the right position, the wheel flanges will crowd the movable rails to one side, and if the operating connections are rigid they will be broken. At non-interlocked switches such connections are usually fitted with a stout spring, not disturbed by ordinary strains or shocks, which will yield if the rails are thus forced out of position, and return them to their former position as soon as the wheels have passed See Figs. 910-917, 919.

Fish Wire. A wire used to draw another through a tube or other opening.

Fixed Signal. A signal of fixed location indicating a condition affecting the movement of a train, as distinguished from signals given by motion of the hand or by a flag or a lamp. Flags or hand lanterns may be temporarily set in fixed locations. All block and interlocking signals are fixed signals.

Floor Push. An electric circuit closer fixed in the floor where the signalman can conveniently close the circuit by pressing downward on a button with his foot. See Figs. 2283-2288.

Fouling Bar. A detector bar, which see, placed at or near a fouling point to prevent the movement of certain functions while a train is on the bar. See **Crossing Bar.**

Fouling Point. In the case of converging tracks, that point where a car running toward the junction would come in contact with a car or train standing or moving on the other track.

Foundation. The foundations for mechanical signal connections—pipes and wires—which are set at suitable intervals along the line, consist usually of heavy planks, or of concrete, or of cast iron.

Frequency. The number of cycles or changes of direction per second in an alternating current. The frequencies most used in commercial work are 25, 60 and 120 cycles per second.

Frequency Relay. An alternating current relay so made that it will act effectively only when energized by an alternating current of a certain frequency.

Front Contact (of a Relay). An electrical contact which is made when the armature of the relay is attracted to the pole piece of the magnet coils by current flowing through the coils. See **Relay** and **Back Contact.**

Front Locking. The mechanical locking in a "Standard" interlocking machine which acts in a plane outside of the tappets. See Figs. 722-772.

Front Rod. See **Switch.** See Figs. 938-939, 941-949.

Frost Board. In a battery chute or well a cover beneath the main cover more effectually to protect the battery from freezing.

Function. In interlocking this word, as the most convenient one available, is used when speaking collectively of switches, signals, movable frogs, derails and any other apparatuses worked or controlled by levers in the machine. For example, a machine from which are worked 10 switches, 5 locks and 10 signals is said to control 25 functions. The American Railway Engineering and Maintenance of Way Association has declared each of the following to be one function or unit: One signal arm; one pair switch points; one derail; one pair movable frog points; one 50-ft. detector bar, with lock; one lock; one scotch block; one torpedo machine; one electric lock; one annunciator or indicator for one route. A committee of signal officers of the New York Central Lines has adopted these values, except that a detector bar without lock is valued at ½ and a

lock (of a detector bar) at ½. A value of 1 is given also to one detector circuit per switch.

Fuse. In electrical work a strip, plate or bar of some readily fusible alloy, designed to melt, and thus break the circuit in which it is placed, if a current passes which is of sufficient power to melt it. The fuse is so designed as to melt before the current is powerful enough to endanger apparatus in other parts of the circuit. The melting of the fuse is due to the heat generated by the passage of the current. Fuses are sometimes enclosed in glass tubes, or are placed between mica strips to prevent injury to surrounding apparatus. A cartridge fuse consists of a piece of metal as above, surrounded by some chemical compound, the purpose of which is to extinguish any arc that might form when the fuse "blows."

Fusee. A chemical fire light, like a roman candle, giving a bright light—red or green or yellow—as a stop or slow signal. The fusee is thrown off the rear of a train as a warning to any following train. Its stick has a sharp point, and it can be thrown so as to stand upright. It is made to burn a definite length of time, either five or ten minutes. At the end of that time it is reduced to ashes. It is the only practicable stop signal in use which can be effectively given at will from a moving train. See **Time Interval System.** See Fig. 3118.

G

Gain Stroke. A device for securing extra stroke in a line of connections used at the end of a long wire line where elasticity and lost motion have reduced the throw. It usually consists of a crank having arms of different length; an escapement crank, a special jaw or a system of pulleys. See 41, 42, 43, Figs. 1023-1098; Figs. 1109-1110, 1351-1352.

Generator, Electric. An electro-mechanical source of electricity. Means for transforming mechanical energy into electric energy. See **Line of Force, Magnetic Flux.** See Figs. 2464-2469.

Gravity Cell. A common form of primary cell using zinc and copper as the elements and a solution of zinc sulphate and copper sulphate for the electrolyte. The zinc in the form of an open wheel or crowfoot is suspended in the top of the jar and the copper in the form of a cylinder or star rests on the bottom and is surrounded with crystals of blue vitriol (copper sulphate). The solution of copper sulphate being heavier than the solution of zinc sulphate, sinks to the bottom, hence the name, gravity cell. The reaction which takes place on a closed circuit is very simple. The copper sulphate is decomposed, depositing metallic copper on the copper plate, and the sulphuric acid thus liberated attacks the zinc plate yielding zinc sulphate. There is a distinct line of demarcation between the two liquids of the electrolyte, and the best test of the condition of the battery is by observing when the zinc sulphate solution increases, extending down near the copper, denoting an excess of zinc and a deficient amount of copper sulphate. The zinc solution should then be drawn off and more copper sulphate solution added. This is done through a tube, so as not to disturb the equilibrium of the liquids. The zinc must be renewed occasionally and the copper taken out and cleaned. A copper plate made unwieldy by accretions of copper must be replaced. The ordinary gravity cell has a voltage of about 0.9 volts, and will remain active for long periods without appreciable polarization on a closed circuit. For this reason it is almost universally used for supplying current to track circuits in signal work and for telegraph circuits where small amounts of current at low voltage are required. See Figs. 2065-2080.

Grid. See **Resistance.** See also Figs. 528-529.

Ground. See **Electric Circuit.**

Ground Lever. A switch or signal lever arranged to be handled by a person on the ground, as at an outlying switch or a derail, in distinction from a lever of an interlocking machine in a cabin. See Figs. 1623-1640.

Ground Signal Post. An ordinary signal post, as distinguished from one on a bridge, bracket post or other structures above the ground.

H

Hayes Derail. A derailing device made by the Hayes Track Appliance Company. See Figs. 1506-1515.

Head Block. The long tie or sleeper on which the points of a switch rest.

Head Rod. The rod next to the front rod of a switch, which see.

High Signal. A general term applied to all full-sized semaphore signals mounted on a post, bridge, building or other structure above the level of the top of a car or locomotive. When two or more high arms are fixed on the same post, the lowest one is usually placed at a minimum height of 20 ft. above the level of the rails and a minimum vertical distance of 6 ft. is preserved between the signals on the same post. All signals for trains running at full speed are high. Low signals (dwarf) are used only for slow movements. See **Dwarf Signal, Pot Signal, Semaphore Signal.**

Highway Crossing Signal. Usually some form of electric bell, which see, mounted on a post near a highway crossing. Used to announce the approach of trains. See Figs. 565-661.

Hold Clear Attachment (Hall Disk Signal). A pair of high resistance auxiliary magnet coils which are thrown into series with the clearing coils at the moment the movement of clearing the signal is completed, thus holding the signal in the clear position with only a small consumption of current. The same principle is sometimes employed in switch indicators. See Fig. 406.

Home Signal. A fixed signal situated at the point at which trains are required to stop when the signal does not indicate "proceed." As a block signal it stands at the entrance to the block. At interlockings home signals stand immediately in the rear of the switches, derails, crossings and drawbridges which they protect. A home signal of an interlocking plant, when cleared, denotes that the route governed by the signal has been made ready for a train movement over it. The term home signal was originally applied on British railroads to the signal mounted on or near the signal box, controlling the entrance of trains into a block section.

A home block signal in a manual or controlled manual system, when in the stop position, must not be passed except on receipt of the proper authority, either written or by flag, obtained from the signalman. An automatic home block signal, when in the stop position, indicates "Stop; wait (a specified

length of time) and proceed cautiously, expecting to encounter obstruction." See **Permissive Block Signaling.** Home block signals, when in the clear position, indicate "Proceed; block is clear."

Semaphore home signal arms are usually made with square ends to distinguish them from **Distant Signals** (which see), the arms of which are made with forked or "fish-tail" ends. On many roads a further distinction is made by using arms with pointed ends for automatic home block signals and square end arms for all other home signals.

In **Three-Position Automatic Block Signaling,** which see, the functions of the home signal and the distant signal are combined in a single arm. See Figs. 129-130, 133-141, 165-176. See also Figs. 150-151, 154-156, 160-176 for home interlocking signal indications. British practice is shown in Figs. 206-213. See **Distant Signal, Advance Signal, Dwarf Signal, Night Signal Indications, Starting Signal.**

Horizontal Chain Wheel. A chain wheel whose axis is vertical. Used to change the direction of a wire line. See Figs. 1339-1350, 1353-1370, 1377-1380.

Horizontal Locking. Mechanical locking arranged in a horizontal plain. See **Saxby & Farmer, Stevens** and **Dwarf Interlocking** Machines. See Figs. 661-721, 874-881.

I

Illuminated Track Diagram. See **Track Indicator.**

Impedance. The effects of self-indication on an alternating current flowing in a coil. Its tendency is to impede the flow of the current in a manner similar to resistance.

Impedance Bond. See **Inductive Bond.**

Indication. 1. The indication of a visual signal is what it tells the approaching engineman. 2. In a power interlocking machine the indication is the electro-magnetic or pneumatic action produced in the machine after a switch or a signal has been moved, *indicating*, by releasing a lock on one or more levers, that the switch movement or the signal movement actually has been completed.

Indicator. See **Block Indicator, Switch Indicator, Track Indicator, Signal Repeater.**

Induced Currents. Currents produced in a closed circuit by the effects of a changing magnetic field. Induced currents may be produced in one circuit by increasing or decreasing the current in a neighboring circuit, or by causing a closed circuit to cut a magnetic field.

Inductance. The induction of a circuit on itself or other circuits; self-induction. That property in virtue of which an electro-motive force, acting on a circuit, does not immediately generate the full current which it is capable of producing in a circuit of that resistance, and when the electro-motive force is withdrawn time is required for the current strength to fall to zero. A quality by virtue of which the passage of an electric current is necessarily accompanied by the absorption of electric energy in the formation of a magnetic field. Time is required to increase velocity in a heavy body by the action of any force; so, also, time is required to produce a current by the action of electro-motive force. See **Induced Currents.**

Induction. See **Induced Currents** and **Inductance.**

Induction Motor. A term usually applied to an a.c. motor having a short-circuited armature. See **Squirrel Cage Armature.**

Inductive Bond. In track circuits, a bond between contiguous rails of the track (the rails being insulated from each other by their usual non-conducting material between their ends), consisting of a coiled conductor, so arranged that the induction taking place in the coils, on the passage of an alternating current, will impede the flow of that current, while at the same time the passage of a direct current is not impeded. Thus the insulation in the joint is made of no effect as regards the direct current (used for propulsion of train), while it still is effective as regards the signaling current.

Inductive Track Bond. See **Inductive Bond.**

Inside Connected Facing Point Lock. See **Facing Point Lock** and Figs. 910-911.

Insulated Rail Joint. The term rail joint is used to denote the bars or plates and bolts used in a railroad track to fasten together the ends at contiguous rails. An insulated joint is one in which a non-conducting body (fiber), about ¼ in. thick, called an end post, is placed between the ends of the rails, and plates or strips of the same material around the bars and bolts so as to prevent electric current from passing from one rail to the other. Fiber plates placed below one or both of the rails are called mats or sole plates. Sometimes wooden blocks, called wood fillers, are placed against the rails in place of or in addition to the iron bars. Insulated rail joints are used at the ends of track circuits. See Figs. 2338-2351.

Insulated Switch Rod. A rod, connecting the two rails of a switch in a railroad track, which is divided into two parts, and the parts held together by a substance which is a non-conductor of electricity. Used in switches, the rails of which are traversed by electric circuits. See Figs. 2365-2366, 2371-2372, 2373-2376, 2378-2390.

Insulated Wire, Specifications for Making. Wires, covered with an insulating material, used as electrical conductors in connection with railroad signals, especially automatic block signals and electric interlocking, where many wires must be laid underground, must withstand severe conditions of heat, frost and moisture; and, by reason of their high cost, must be durable. To meet these conditions, carefully tried regulations have been prescribed to govern the manufacture of wire and the manufacture and application of the insulating materials; and the most essential features of these regulations have been formulated as specifications to be followed in the purchase of such wires by railroad companies.

Wires which are to be strung on poles, after the fashion of telegraph lines, are used both bare and insulated. As the insulation adds materially to the cost it is omitted where the likelihood of disturbance by breakage of other wires or from other causes is small; while on railroads of heavy traffic and where accidental crosses with other wires by deranging signals might cause serious or frequent delays to trains, insulation is used; usually of the kind called "weather-proof." This consists of cotton braid saturated with an insulating compound. It must be of sufficient thickness and toughness to prevent electrical contact in case another wire, as for example, one strung above it on the same poles, should fall upon it.

For underground work, compounds containing 30 per cent. of rubber, much more costly than weather-proof insulation, are most commonly used. For these the specifications given next below are

those of the Railway Signal Association, adopted October 17, 1906. A number of important railroads buy insulated wires under specifications differing in a few paragraphs from those adopted by the Association; and one of these railroad specification codes, that of the Southern Pacific, is given below, following the Association's specifications. The significant difference is in the paragraphs stipulating the percentage of rubber and other substances. (See paragraphs 2 and 10 Association code; paragraph *e*, Southern Pacific code). Voltage and insulation tests also show differences. Those compounds which contain non-mineral matter other than rubber are made by secret formulas, and those who buy them depend, for quality and durability, not on a knowledge of the nature of the compound, but on the reputation or the guaranty of the maker.

Specifications for Rubber Insulated Signal Wire. Adopted by the Railway Signal Association, October, 1906—600 volts or less.

1. *Conductors.* Conductors must be of soft-drawn, annealed copper wire having a conductivity of not less than 98 per cent. of that of pure copper. Each wire forming a conductor must be continuous without splice throughout its length, must be uniform in cross-section, free from flaws, scales and other imperfections and provided with a heavy uniform coating of tin.

2. *Rubber Insulation.* The vulcanized rubber compound shall contain not less than 30 per cent. nor more than 33 per cent. by weight of fine dry Para rubber which has not previously been used in rubber compound. The gum itself shall not contain more than 3½ per cent. of resinous extract. The remaining 70 per cent. of the compound shall consist of mineral matter only. The insulation must be tough, elastic, adhering strongly to the wire, must be homogeneous in character and placed concentrically about the conductor.

3. *Taping and Braiding.* (a) The rubber insulation must be protected with a layer of cotton tape thoroughly filled with a rubber insulating compound, lapped one-half its width and so worked on as to insure a smooth surface.

(b) The outer braid must consist of one layer of closely woven cotton braiding at least $\frac{1}{32}$-in. thick, saturated with a black, insulating, weatherproof compound which shall be neither injuriously affected by nor have injurious effect upon the braid at a temperature of 200 deg. Fahrenheit.

4. *Tests.* The manufacturer must provide at his factory all apparatus and other facilities needed for making the required physical and electrical tests and must provide the company's representative with all facilities for assuring himself that the 30 per cent. of rubber as above specified is actually put into the compound. The inspector shall not be privileged to ascertain what mineral ingredients are used in making up the remaining 70 per cent. of the compound. The manufacturer shall give free access to the place of manufacture and opportunity to test at all necessary times. Tests may also be made upon the finished product after delivery, and the wire will be rejected if it fails to meet the requirements of the specifications. The manufacturer must pay freight charges for return of all wire that may be rejected by the railroad company.

5. *Physical Test of Copper Conductors.* Each solid conductor must stand an elongation of 25 per cent. of its length in 10 in. before breaking. In torsion it must stand before breaking thirty twists in 6 in. It must be capable of being wrapped six times about its diameter and unwound without showing signs of breakage after this process has been gone through twice. The tension and torsion tests will be made on separate pieces of wire.

6. *Conductivity Test of Copper.* The conductivity of the copper shall be determined by measuring the resistance of a length of the wire and comparing with Matthiessen's standard of copper resistance.

7. *Tests of Tinning.* Samples of the wire shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of sp. g. 1.088 for one minute. They shall then be rinsed in clear water and immersed in a sodium sulphide solution of sp. g. 1.142 for 32 seconds and again washed. This operation must be gone through with four times before the wire becomes clearly blackened.

8. *Tests of Braiding.* A 6-in. sample of wire, with carefully paraffined ends, shall be submerged in fresh water of a temperature of 70 deg. Fahrenheit for a period of twenty-four hours. The difference in weight of the sample before and after submersion must not be more than 10 per cent. of the weight of the sample before submersion, less the weight of the copper and vulcanized rubber.

9. *Physical Tests of Rubber Insulation.* A sample of the vulcanized rubber insulation not less than 4 in. in length shall have marks placed upon it 2 in. apart. The same shall be stretched until the marks are 6 in. apart and then at once released. One minute after such release the marks shall not be over 2⅜ in. apart. The sample shall then be stretched until the marks are 9 in. apart before breaking, and must have a tensile strength of not less than 800 lbs. per square inch.

10. *Chemical Tests of Rubber Insulation.* The vulcanized rubber compound shall contain not more than 6 per cent. by weight of acetone extract and not more than seven-tenths of 1 per cent. of free sulphur.

11. *Electrical Tests of Rubber Insulation.* The circular mills cross-section, the thickness of the rubber insulation (measured at the thinnest point), the minimum insulation resistance in megohms per mile and the dielectric strength of the various sizes of wire shall conform to the following table:

Size B. & S. gage.	Area in circular mills.	Thickness of wall of insulation.	Insulation resistance. megohms per mile.	Test voltage alternating current.
0	105,592	$^1/_8$-in.	1,200	10,000
1	83,694	$^1/_8$-in.	1,300	10,000
2	66,373	$^1/_8$-in.	1,400	10,000
4	41,742	$^3/_{32}$-in.	1,300	9,000
6	26,250	$^3/_{32}$-in.	1,500	9,000
8	16,509	$^3/_{32}$-in.	1,700	9,000
9	13,090	$^5/_{64}$-in.	1,700	7,000
10	10,380	$^5/_{64}$-in.	1,800	7,000
12	6,530	$^5/_{64}$-in.	2,000	7,000
14	4,107	$^5/_{64}$-in.	2,100	7,000
16	2,583	$^1/_{16}$-in.	1,900	4,000
18	1,624	$^1/_{16}$-in.	2,000	4,000

The test for insulation resistance must be made upon all wire after at least forty-eight hours immersion in water, and while still immersed, results being corrected to a water temperature of 60 deg. Fahrenheit. Tests must be made before the application of tape, braid or other covering with a well-insulated battery and galvanometer, with not less than 150 volts, and readings must be taken after one minute's electrification. The test voltage must be applied to the completed length of wire before the insulation test for a period of five minutes, using alternating current from a generator and transformer of ample capacity.

SOUTHERN PACIFIC SPECIFICATIONS.

The manufacturer must provide at his factory all apparatus and other facilities needed for making the required physical, chemical and electrical tests. Factory tests will be made under the direction of the railroad company's inspector upon notice from the manufacturer. The manufacturer shall give free access to the place of manufacture and opportunity to test at all necessary times.

Tests will also be made upon the finished product after delivery, and all lots of wire or individual coils not meeting the requirements of these specifications will be rejected and returned to the manufacturer at his expense.

No. 1.—**General Specifications of Solid Wire for Underground Work.**

a. Conductors must be of soft-drawn, annealed Lake copper, free from cracks, splits, scales, flaws, inequalities, or other imperfections, true to gage, with variation not over 1 mil. in diameter and without splices in copper, heavily and evenly tinned, and furnished in lengths of not less than 1,500 ft.

b. Each solid conductor must stand an elongation of 25 per cent. of its length in 10 in. before breaking. It must withstand, without break, thirty twists in 6 in., and must be capable of being wrapped six times about its own diameter and unwrapped without showing signs of break after this process has been gone through twice. These tests to be made on separate pieces of wire.

c. The solid conductor must have a conductivity of not less than 98 per cent. of that of pure copper by Matthiessen's Standard.

d. Samples of the wire shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity of 1.088 for one minute. They shall then be rinsed in clear water and immersed in a sodium sulphite solution of specific gravity 1.142 for thirty seconds and again washed. This operation must be gone through with four times before the wire becomes clearly blackened.

e. The vulcanized rubber compound must contain at least 30 per cent. of the best grade of fine Para rubber. It must be tough, elastic, homogeneous in character and must be placed concentrically about the conductor.

f. A piece of the rubber insulation 4 in. in length must be stripped from the wire and marks 2 in. apart placed thereon. This piece must then be stretched until the marks are 6 in. apart, then, upon being released, the marks shall not be over 2½ in. apart. The piece must then be stretched until the marks are 7½ in. apart before breaking.

g. The rubber insulation must not crack or break upon the wire being sharply bent or kinked, nor be injuriously affected by a range of temperature from zero to 150 deg. Fahrenheit.

h. The circular mills cross-section, the thickness of the rubber insulation (measured at the thinnest point), the minimum insulation resistance in megohms per mile and the dielectric strength for the various sizes of wire must conform to the following table:

Size B. & S. gage.	Area in circular mills.	Thickness of wall of insulation.	Insulation resistance. megohms per mile.	Test voltage alternating current.
0	105,592	1/8-in.	800	8,000
1	83,694	1/8-in.	800	8,000
2	66,373	1/8-in.	800	8,000
4	41,742	3/32-in.	800	3,000
6	26,250	3/32-in.	900	5,000
8	16,509	3/32-in.	900	5,000
9	13,090	5/64-in.	900	4,000
10	10,380	5/64-in.	900	4,000
12	6,530	3/64-in.	600	2,000
12	6,530	5/64-in.	1,200	4,000
14	4,107	3/64-in.	750	2,000
14	4,107	5/64-in.	1,500	4,000

The test for insulation resistance must be made upon all wire without tape or braid, and after forty-eight hours' immersion in water at a temperature of 60 deg. Fahrenheit. Tests must be made with well-insulated battery and galvanometer, with not less than 150 volts, and reading must be taken after one minute's electrification.

The test voltage must be applied to the completed length of wire after the insulation test for a period of five minutes, using alternating current from a generator and transformer of ample capacity.

i. The rubber insulation must be protected with a layer of cotton tape thoroughly filled with a rubber insulating compound, and lapped one-half its width. The tape must not adhere to the rubber, and must be so worked on as to insure a smooth surface. Over the tape there must be one layer of closely woven cotton braiding 1/32 in. thick, saturated with a black, insulating, waterproof compound, which must not have any injurious effect on the braid or rubber insulation. The outside must be made smooth with a suitable finishing wax.

No. 2.—**Flexible Wire.**

a. Flexible wires must conform to General Specifications No. 1, each wire to be tinned separately and cabled together concentrically per following table:

Size B. & S. G.	Strand.	Wall insulation.
6	37 No. 22	3/32-in.
8	37 " 24	3/32-in.
9	37 " 25	5/64-in.
10	27 " 24	5/64-in.
12	27 " 26	3/64-in.
12	27 " 26	5/64-in.
14	19 " 27	3/64-in.
14	19 " 27	5/64-in.

No. 3.—**Aerial Wire.**

a. Aerial wire must conform in all respects to General Specifications No. 1, except that tape is not required.

Insulation. The protection of electrical conductors from other conducting substances and from the ground.

Interlocking. A short name for interlocking plant. "An arrangement of switch, lock and signal appliances so interconnected that their movements must succeed each other in a predetermined order." (A. R. A.) The term includes the cabin, the machine, the switches and signals and all the connections and appurtenances. See **Interlocking Plant.**

Interlocking Machine. An assemblage of switch levers and signal levers, in a frame, with connections so arranged that the movement of a lever, or its unlocking, preparatory to its movement, may be made to lock any or all other levers in the frame. The interlocking is used to insure the movement of levers always in a predetermined order, thus preventing the giving of a conflicting or dangerous signal indication by mistake or inadvertence. The most common form of interlocking machine is the Saxby & Farmer, Figs. 661-721. Others are the Johnson, Figs. 773-802; the "Standard," Figs. 722-772; the National, Figs. 803-873; the Stevens, Fig. 874, and several dwarf machines, Figs. 875-881. Machines in which switches and signals are moved by hand-power (called "mechanical") have latch locking, which see. See **Power Interlocking Machine.**

Interlocking Plant. A group of interlocking functions controlled from one interlocking machine, the machine and all its accessories.

Interlocking Relay. Two relays on a single base, so arranged that the armature of one can be made to lock that of the other, either in its closed or its open position. See Figs. 586-597.

Interlocking Station. A place from which an interlocking plant is operated; usually a cabin or "tower,"

the principal room being that occupied by the signalman and containing the interlocking machine.

Ionize (verb). To break up into ions. Ions are electro-positive particles of matter smaller than atoms. See **Mercury Arc Rectifier.**

J

Jaw. A forging attached to a pipe line for connecting it with the machine or with a crank, a compensator, or any other device. See Figs. 1023-1098.

Johnson Interlocking Machine. An interlocking machine with the locking bars and tappets arranged in a vertical plane beneath the floor. See Figs. 773-802. This style was first made in America by the Johnson Railroad Signal Company in 1889.

Jumper. An insulated electric conducting wire used to preserve the continuity of a track circuit past a place in the track, as a crossing of other electrified tracks, where the rails cannot be suitably insulated.

Junction Box. A box to which are run a number of electrical conductors for convenient connection, disconnection, inspection or change of connections. See Figs. 2392-2399.

K

K.W. Abbreviation for Kilowatt.

Kerite. A compound used for insulating electric wires, composed of pure rubber and crude kerite. The kerite increases the durability of the rubber.

Kilowatt. Commonly abbreviated to k.w. One thousand **Watts,** which see. The common unit of rating for the output of electric generators. One horsepower equals .746 k.w.

Kilowatt Hour. The common unit of work as applied to electrical machinery, equal to the expenditure of one kilowatt for one hour.

Knife Switch. A common form of switch for making or breaking an electrical circuit, consisting of a blade like the blade of a knife, which may be pushed between two spring contacts. It is pivoted at one end, and has a non-conducting handle. Single or multiple blades may be used, all attached to the same handle. A switch may be either single or double throw. See Figs. 2282, 2293, 2304, 2498-2501.

L

Lamp Signal. A common form of lamp for fixed signals is a rectangular sheet metal case, with a magnifying lens on the front side, and, if needed, a small glass-covered opening on the back side to enable the signalman or inspector to know whether the light is burning. For signals, such as clockwork signals, which turn on a vertical spindle or shaft, the lamp has lenses on all four sides, two opposite each other, giving the clear indication and the two others opposite to each other giving the stop indication. See **Long-Time Burner; Back Light.** See Figs. 2774-2799, 3093.

Lampman. The person who cleans, fills and cares for the lamps of signals. Ordinary lamps are usually lighted and put in position each afternoon and taken down and extinguished each morning. Lamps with "long-time" burners remain in place, lighted, continuously for several days and nights.

Latch Locking. Interlocking of one lever with another by means of the latches of the levers; necessary in mechanical interlocking to effect preliminary locking. In grasping a lever preparatory to moving it the signalman unlatches it, and in so doing locks all conflicting levers before his lever moves, and the unlocking of other levers which properly comes after this lever movement is effected by the return of the latch to its notch after the lever has completed its stroke. See Figs. 661-873.

Lazy-Jack Compensator. See **Compensator.**

Lead Out. In an interlocking plant the pipes, wires and chains, and their supports and accessories, in and near the cabin which *lead out* from the cabin to the switches, signals, etc. See Figs. 1484-1497.

Leonard's Controlled Manual System. An arrangement of signal apparatus, devised by M. B. Leonard, and used on parts of the Chesapeake & Ohio (single track), in which a modified form of controlled manual instrument is used for blocking in both directions. For releasing the plunger a track instrument is used, instead of a short track circuit. There are no recent installations of this, but the original instruments are still in use on the Chesapeake & Ohio. Most or all of the sections have since been double-tracked.

Lever Locking. The locking of interlocking switch or signal levers by the movement of levers, as distinguished from latch locking, which see.

Lightning Arrester. A device to overcome the effects of lightning. Lightning is a high potential alternating current. It therefore tends to jump across short gaps especially from one metallic point to another; also it has difficulty in flowing through a coil. (See **Impedance.**) Lightning arresters are of two kinds—spark gap and impedance arresters. The former consist of two or more metallic plates, with tooth edges placed in close proximity to each other, one or more connected to ground, the others to the circuit to be protected. Impedance arresters consist of a coil of large-sized wire which checks the lightning discharge. Sometimes a ground plate is placed near the coil, so that the lightning may jump to it and thus reach ground. See Figs. 2400-2425.

Line of Force. A unit of measurement of the intensity of a magnetic field. It is purely imaginary, but of great convenience in electrical calculations. When so used it is always spoken of, in connection with the area of the field, in centimeters. The current generated in the armature of a dynamo is said to be due to the fact that the armature coils cut the lines of force of the magnetic field, and the strength of the current is proportional to the number of lines of force cut per second.

Lock and Block. A common name for the **Controlled Manual Block System,** which see.

Lock, Electric. An electro-magnetically actuated locking dog. As applied to signal apparatus, the dog or lock falls by gravity to lock the lever of an interlocking machine, or a switch, or a drawbridge, to prevent or restrict its movement, unless it (the dog) is withdrawn by the attraction of an electromagnet forming a part of the device. See **Indication.** See Figs. 2318-2337.

Lock Rod. A switch rod which receives the plunger of the lock. See **Switch; Facing Point Lock; Switch and Lock Movement.** See Figs. 932-939, 941-949, 2373-2374.

Locking. The rods, bars, dogs, tappets and other apparatus, in an interlocking machine, by which the interlocking is accomplished. See Figs. 661-873.

Locking Bar. A bar running lengthwise in the interlocking machine, to which the locking dogs are attached. See **Locking.**

Locking Bar. A British term for detector bar, which see.

Locking Dog. A variously shaped block attached to a locking bar. Through it the interlocking is accomplished. See **Locking.**

Locking, Electric. The locking of the levers of an interlocking machine or of switches or drawbridges by electric locks (which see), or other means, to insure the integrity of a route, or portion of a route, during the movement of a train over that route. Electric locking is accomplished by controlling the current for operating the locks or other apparatus by track circuit relays or track instruments, or by circuit controllers actuated by signals, switches, drawbridges, etc. See Figs. 1995-2016.

Locking Sheet. A statement in tabular form of the locking operations which are provided for in a given interlocking machine. It shows the sequence in which levers must be locked or unlocked preparatory to giving clear signals for each route in the plant. See Figs. 612-659.

Long-Time Burner. A burner used in signal lamps, in which the wick, treated chemically so as to make it resist rapid combustion, may be so correctly adjusted as related to the lens and the reflector of the lamp that the flame of about 1 candle-power will burn continuously for from 100 to 150 hours. With lamps on high posts and scattered over miles of territory this affords a marked economy in attendance as compared with lamps needing to be trimmed or adjusted every day. See Figs. 2776-2788, 2792-2793.

Longitudinal Locking. That part of the mechanical locking apparatus which extends longitudinally in the locking frame. See Figs. 663-881.

Lower Quadrant. One of the quarters of a circle below its horizontal axis; a term used of semaphore signals, in which the arm, normally horizontal (indicating stop), is turned downward to give other than stop indications.

M

M. P. F. Abbreviation for Movable Point Frog.

Machine Framing. The frame in an interlocking cabin on which the interlocking machine rests; usually set on a foundation separate from that which supports the walls of the building. See Figs. 1484-1493, 2993-2996, 3004-3005.

Magnet. A body possessing the power of attracting magnetizable bodies like iron filings. Magnets have two poles called north and south, respectively. The north pole of one magnet will repel the north pole of another magnet, but will attract the south pole of a second magnet. A magnet is said to possess a magnetic field consisting of lines of force, which see. The lines of force are assumed in passing through the magnetic field to come out at the north pole and go in at the south pole. The lines of force form a closed magnetic circuit. If a magnetizable body is brought into a magnetic field, the lines of force are concentrated on it and pass through it. The body thereupon becomes magnetic by induction. See **Electro-Magnet.**

Magnetic Flux. The number of lines of magnetic force that pass or flow through a magnetic circuit; the total number of lines of magnetic force in any field. The magnetic flux is also called the magnetic flow. See **Line of Force.**

Magnetic Shading. Preventing magnetic induction from taking place by interposing a metallic plate or a closed circuit of insulated wire between the body producing the magnetic field and the body to be magnetically shaded; or by placing a small closed circuit in a part of the pole piece of a magnet. See Figs. 530-534.

Maintainer. The person in immediate charge of the maintenance of signals.

Manual Block System. A block system in which the block signals at a block station are moved by hand by an attendant, on information conveyed to him from adjacent block stations by Morse telegraph, needle telegraph, telephone or single-stroke electric bells sounded in accordance with a prescribed code. The term "manual" is used to distinguish such a system from the **Automatic Block Signal System,** which see, in which the signals are worked by mechanical or electrical power controlled automatically by the passage of a train into, through and out of a block section. The **Controlled Manual Block System** which see, differs from the simple manual block system by the introduction of electric locking devices attached to the levers by which the signals are moved, so that to clear a signal admitting a train into the block, the simultaneous action of the signalmen at both ends of the block is required.

With the manual block system the blocks are made from 1,000 ft. to 10 miles or more long, and where the traffic is light the station agents at small stations, being telegraphers, act as block signalmen. The usual method of communication in the United States is the **Morse Telegraph** (which see), while in Great Britain the needle telegraph and electric bells are used. Each block station has two home signals, one to govern the movement of trains in each direction. On American single-track lines the arms for both directions are often placed on the same post. **Distant Signals** and **Advance Signals,** which see, are also frequently installed. All of these signals are moved by levers in the signal cabin and stand normally in the stop position, being cleared only on the approach of a train, for which

TRANSCRIPT OF PART OF A BLOCK SIGNALMAN'S DAILY RECORD OF TRAINS.

Eastward

TRAIN	Eng.	Da D	Da Track	Ki Track	Ki A	Ki D	Ki Track	Cn D
70		209	1	1	215	217	1	221
66		446	1	1	—	450	1	455
	1061	450	2	2	—	505	2	—
14		503	1	1	—	507	1	511
	1060	515	2	2	—	522	2	—
78		526	1	1	—	531	1	536
10		601	1	1	—	605	1	608
	728	602	2	2	—	610	2	—
6		613	1	1	—	616	1	619
	1042	625	1	1	—	632	1	640

NOTE.—This is the record kept at Ki station. "Da" is the station next west and "Cn" is the station next east. This is for a four-track railroad. With a double-track line the track number would not be required.

the block ahead is clear, and restored to the normal position after the train has passed.

Each signalman keeps a record of passing trains in the form substantially like that shown below for station Ki. The column Da shows the time trains were reported as leaving the next station to the west.

The column Ki shows the time of trains arriving at and departing from this station, and the column Cn shows the time trains were reported as leaving the next station to the east.

On some roads the manual block system is used with a bell code in place of the telegraph. The following table gives the principal clauses of the code of signals adopted which cover most of the necessary information to be conveyed:

Rings.	*Meaning.*
1.	Acknowledgment of any signal except as noted.
2.	Yes.
3.	Is block clear? Answer by 2 or 5.
4.	Train has entered block.
5.	Block not clear.
2-1.	No.
2-4.	Has train cleared? Answer 4-2 or 5.
3-3.	Train is on siding clear of main track.
3-3-3.	Train to you broken in two. Answer by repeating 3-3-3 to sender.
4-2.	Track has cleared.
9.	Stop train. Has no markers.

See **Permissive Blocking, Absolute Blocking.**

Maximum Traffic on a Block Signaled Line. See **Block Signaling for Maximum Traffic.**

Mechanical Interlocking. This term is the general designation of the machine and the other apparatus at an interlocking plant where the switches and signals are moved by means of rods or wires by manual power; distinguishing such a plant from one in which compressed air or electricity is the force which moves the switches and signals.

Mechanism. See **Signal Mechanism.**

Mechanism Case. The housing for a signal mechanism.

Megohm. One million ohms. See **Ohm.**

Mercury Arc Rectifier. See Figs. 2487-2496.

Mercury Contact Relay. A relay, the armature of which closes the local circuit or circuits by making a contact through mercury. See Fig. 2582.

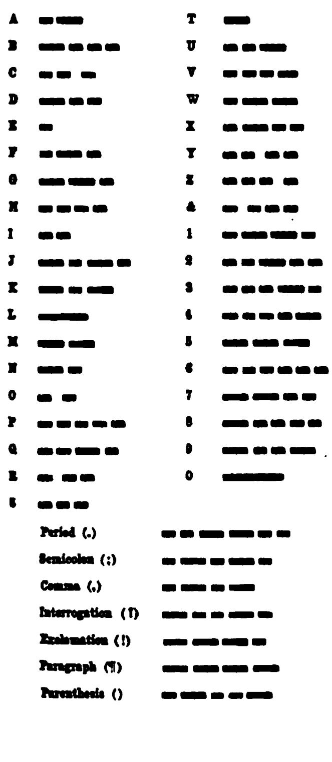
Mil. A unit of length equal to .001 in., used in measuring the diameter of wire. See **Circular Mil.**

Milampere. The one thousandth part of an **Ampere,** which see.

Monnot Wire. See **Copperclad Wire.**

Morse Alphabet. The arbitrary code of dots and dashes representing the letters of the alphabet used as the guide in making and breaking the telegraph circuit. The American code is given below:

MORSE TELEGRAPH ALPHABET.



Morse Telegraph. A method of communicating between two distant points by sending electric impulses over a wire, the circuit being made and broken according to the **Morse Alphabet,** which see. The signals thus formed are received and made audible by an electro-magnetic sounder or receiver. Invented in 1837 by S. F. B. Morse. First used publicly in 1844. See **Needle Telegraph.** See Figs. 2882-2885.

Motor, Electric. A device for transforming electrical power into mechanical power. All practical electric motors depend for their operation on the tendency to motion in a magnetic field of a conductor carrying a current or on magnetic attraction or repulsion. The entire magnetism may be produced by the current, or part may be obtained from permanent magnets and the rest from electro-magnets (Houston). See Figs. 417-418, 428, 2464-2469.

Multiple (Electricity). Two or more pieces of electrical apparatus, such as batteries, indicators, lamps, motors or contact points, are said to be connected in multiple when they are connected across two mains leading from the source of supply. A part of the current flows through each lamp, motor or other function. Pieces of apparatus thus connected are also said to be connected in parallel.

N

National Interlocking Machine. An interlocking machine having vertical locking arranged in a frame below the floor. Originally made by the National Signal Company. See Figs. 803-873.

Needle Telegraph. An apparatus by which signals transmitted from one point are received at the other end of the line by observing the movements to the right or left of a vertical needle over a dial. The single needle apparatus of Wheatstone consists of an astatic needle mounted inside a double coil of fine wire connected to the external circuit and free to rotate on a horizontal axis, carrying on its end the pointer, projecting through the dial. The needle is made to turn to the right or left by reversing the direction of the current flowing through the coil and the external circuit. The sender consists of a double key or tapper. Depressing one key sends a negative current through the line and turns the needle to the right. Depressing the other key sends a positive current from the battery through the line and deflects the needle to the left. The movement of the needle to the left indicates a dot in the **Morse Alphabet,** which see, and a movement to the right indicates a dash. In Great Britain the needle telegraph is used in manual block signaling between adjoining signal cabins. An elaborate bell code is usually used in conjunction with it. See **Morse Telegraph.** See Figs. 236-239.

Neutral Relay. An ordinary direct current electromagnetic relay, workable by a direct current, regardless of the polarity of the current. See Figs. 2556-2567, 2570-2573, 2576-2589.

Night Signal Colors. Until within a few years the general practice with signal lights throughout the United States was *white* (an ordinary oil-lamp flame) for clear or proceed, *green* for caution (both for permissive block signaling and for the adverse indications of distant signals), and *red* for stop. Since 1899 the green-yellow-red system has gained favor; *green* for clear or proceed, *yellow* for adverse distant and *red* for stop. In Great Britain green has been the "clear" color universally for 15 years or more;

but yellow is not used, as in that country distant signals have the same night colors as home signals. On the Chicago & North-Western for many years green has been the "clear" color, and the adverse distant signal is given by a green and a red light side by side. A number of roads have abandoned red as the stop indication in dwarf signals and have substituted purple or blue. These are poor colors, but are practicable at the short distances which dwarf signals have to be seen. See Figs. 129-176.

Normal. The position in which a lever in an interlocking machine stands when the corresponding switch or signal is in its normal position. A switch is "normal" when set for the main track; a derailing switch is normal when set to derail; a home signal when it indicates stop; a distant signal when it indicates caution. Automatic block signals in their simplest form are called "normal clear," as at all times when their block sections are unoccupied with the switches closed and all apparatus in order the home signals stand at "clear," indicating "proceed." In a modified arrangement, called "Normal Danger," the home signals indicate "stop" at all times (even when the block is clear), except when a train is approaching, and then they indicate "proceed" only in case the block is clear. The practice thus resembles the practice in manual signaling, where home signals are always kept in the stop position except when it is necessary to clear them for the passage of a train. On a double-track or a four-track railroad the normal movement of trains, on a given track, is that in which trains regularly run on that track. By special order of the train despatcher trains may be moved in the opposite direction against the "current of traffic."

O

Off. In operating signals, a two-position semaphore signal, when in the position indicating proceed (either at full speed, as at a home signal, or otherwise, as at a distant signal) is said to be "off." When in the other position the signal is said to be "on." This term is common in Great Britain, but not common in America.

Ohm. The unit of electric resistance. Such a resistance as would limit the flow of electric current under an electromotive force of 1 volt to 1 ampere. The standard of measurement is the resistance of a column of pure mercury 1 square millimeter in cross-section and 106 centimeters long at a temperature of 0 deg. Cent. or 32 deg. Fahr.

Ohm's Law. The expression $I = \frac{E}{R}$ is commonly called Ohm's law. It shows the relation between current, voltage and resistance. It may be expressed as $\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$, $\text{Ohms}, = \frac{\text{Volts}}{\text{Amperes}}$ or $\text{Volts} = \text{Amperes} \times \text{Ohms}$. See **Ampere.**

Oil Crank Box. A water-tight box, in which a crank is pivoted. It is filled with oil and used in connection with oil pipes, which see. See also Figs. 1433-1441.

Oil Pipe. A pipe within which a wire or a second pipe for the operation of an interlocking function is laid where it must run underground, as at a highway crossing. After the insertion of the operating pipe or wire the remaining space is filled with oil to reduce friction and exclude moisture. Stuffing boxes are provided at each end to prevent the escape of the oil. See Figs. 1433-1441.

Okonite. A compound used for insulating electric wires, composed of pure rubber and mineral matter.

On. In operating signals, a two-position semaphore signal, when indicating *stop* (as at a home signal) or *stop at the home signal* (as at a distant signal), is said to be "on." This term is common in Great Britain, but not in America. See **Off.**

Open Switch. Set so as to turn trains away from the main track; said of outlying switches when set for the side track. At interlockings, where switches are constantly under the charge of an attendant, the term is inappropriate, as all such switches are suitably safeguarded by signals; but it is used everywhere to describe a derailing switch which is set to turn trains off the track.

Operator (Telegraph). On those American railroads where the "telegraph block system" is used and where it is worked by persons whose principal occupation has been, and perhaps continues to be, telegraphing, the old title continues in use, and the terms, "operator" and "signalman," are used indiscriminately.

Outlying Switch. A switch not connected with an interlocking plant. Such a switch may be locked by a key which is kept by the nearest signalman, or by a lock controlled from the nearest signal cabin by an electric connection. In some cases where neither of these arrangements is in force telephone communication is maintained between the switch and the nearest signal cabin, so that trainmen using the switch can receive from the signalman instructions as to the use of the main track.

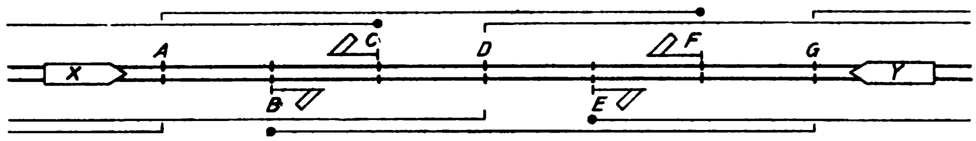
Outlying Switch Lock. An electric switch lock, which see, applied to an outlying switch, which see.

Outside Connected Facing Point Lock. See **Facing Point Lock.** See also Figs. 912-915, 919.

Overlap. An arrangement of track circuits for block signals, originally introduced as a substitute for distant signals. With a block section extending from A to B a track circuit for, say, 2,000 ft. beyond B is arranged, so that when it is occupied by a train (or car) the signal at *A* will be held in the stop position, the same as though the train were between A and B. Thus, when signal A is cleared, a train passing it is not only assured of a clear track to B, but also is assured that signal *B* may be overrun 2,000 ft. without danger of collision with the preceding train. Where a line is fully equipped with distant signals, so that enginemen will never need to slacken speed to make sure of the indication of the home signal before passing it, the overlap is generally deemed unnecessary, and it is used with distant signals only on a few lines—the New York Central electrified lines and the Interborough (New York) subway express tracks being the most prominent. Both in these situations and where used without a distant signal, and as a substitute for it, the overlap is criticised because it tends to impair discipline, its presence suggesting that a signal indicating "Stop" (at that signal) need not be strictly obeyed. In the New York subway (Interborough) and on the electrified lines of the New York Central, where overlaps and distant signals are both used, the overlaps are in most cases the full length of the block sections. In the subway this means about 900 ft. On single track lines, automatic block signals are arranged with overlaps, so as to prevent

the occurrence of a collision between trains moving toward each other, which without the overlap might pass clear signals at the same moment. The opposing signals are so situated that each train will encounter a stop signal before it can meet the other.

With the manual block system permissive blocking is an expedient to obviate the expense of maintaining short block sections and is ordinarily allowed only with freight and work trains, absolute blocking being enforced before and behind pas-



Arrangement of Overlaps for Automatic Block Signals on a Single Track Line.

The diagram above shows a typical arrangement of automatic block signals on a single track road. Signal B is controlled by track circuits to the point G and Signal F, similarly to A. Suppose two approaching trains, to be represented by X and Y. Assume train Y to pass signal F at clear at the same instant that train X passed point A. Train Y would set signal B at stop and train X would set signal C; and the trains would be held at signals C and B, respectively. If the track sections were arranged so that train X could pass signal B at clear and Y pass F at clear at the same instant, Y might possibly be stopped at C, but X, having a clear signal at B, would continue on through the block and collide with Y. In the positions shown the two trains would set signals C and E at stop. See Figs. 221-222, 373-374, 379, 383-389, 395-398, 487, 509, 524, 525, 536.

Overstroke. Excess throw in a pipe or wire line.

P

Pan Copper. A copper element of peculiar shape used in gravity batteries. See Figs. 2076-2080.

Parallel (Electricity). See **Multiple.**

Parallel Bar. A British term for detector bar, which see.

Permissive Block Signaling. Permitting one or more trains moving in the same direction to enter a block section before the last preceding train has passed out at the other end. In such cases the following train is allowed to proceed, expecting to find the track blocked, and prepared to stop before reaching any obstruction, without being warned by a flagman or otherwise. Permission to proceed is given by a written card from the signalman; or by signal indication (the intermediate position of a three-position signal) or by flag or hand lantern. In automatic block signal systems the practice generally is permissive, for if a signal were out of order and indicating stop the line would be blocked until the signal could be repaired. The most common rule where automatic signals are used is to stop at a signal indicating stop, wait one minute and then proceed through the block with speed under control. On those lines of the New York subway which have automatic block signals, and in a few other places, trains are forbidden to pass a stop signal without first sending a flagman ahead. On single-track roads with automatic signals it is the rule to send a flagman ahead. After waiting long enough for him to go a safe distance, the train proceeds at low speed under his protection. He must be sent forward at once, because it is impossible to know whether the stop indication is due to a failure of the apparatus or to the presence in the block of an opposing train. On the Cincinnati, New Orleans & Texas Pacific the passenger trains are provided with light track velocipedes, carried in the baggage car for use in flagging ahead.

senger trains. See **Caution Card.** For common arrangements of permissive block signals see Figs. 226-228. With controlled manual signals, permissive blocking is usually forbidden, as the "control" attachments would be made useless.

Permissive Card. See **Caution Card.**

Phase. See **Alternating Current.**

Pipe Carrier. A grooved roller supported in suitable bearings. In a mechanical interlocking, a series of pipe carriers is used to support a line of pipe for operating a switch or signal. Where only one roller is used it is called a one-way pipe carrier; two rollers, a two-way carrier, etc. A small top roller is frequently used to keep the pipe in place in the grooved roller. See Figs. 1163-1164, 1206-1241.

Pipe Carrier Stand. A casting carrying the grooved rollers of a pipe carrier and bolted to the foundation. See **Pipe Carrier.**

Pipe Compensator. A device for automatically compensating for the changes in the length of a pipe line due to temperature changes. Such a device is necessary in long pipe lines in order to preserve a uniform range of movement at the end connected to the switch or signal. The simplest form consists of a straight lever pivoted at the center and having one section of the pipe attached to one end and the adjoining section to the other end. If one or more compensators are placed between the leadout and the outlying end of the pipe line, each in the middle of the section of pipe to be compensated by it, the only effect of changes of temperature will be to change the angle of the compensating lever. In order to keep the pipe in a straight line a form of self-contained double compensator called a **Lazy Jack,** which see, is most frequently used. Where a line of pipe changes direction, the crank at the angle can be arranged to serve as a compensator. See **Compensator.**

Pipe Coupling. See **Pipe Plug.** See also Figs. 1008-1013.

Pipe Line. The common name for the line of rodding which connects a switch or signal to its lever, such rodding being usually made of 1-in. wrought iron or steel pipe. In Great Britain rods of L shape are used extensively. See Figs. 1272, 1497.

Pipe Line Lug. See Figs. 1023-1098.

Pipe Plug. A piece of round iron rod, used to stiffen pipe at a joint. It is used in addition to the pipe sleeve and is riveted to the pipe. See Figs. 1008-1013.

Pipe Run. In an interlocking plant, an assemblage of pipe lines, with their carriers and foundations in a common course. See **Pipe Line.**

Pit. A depression below the floor level of an interlocking cabin in which the leadout apparatus is situated.

Plunge (verb). In controlled manual block signaling, the operation which is required to release the signal lever at the distant station. See description of Controlled Manual Apparatus, Figs. 251-272.

Plunger. See **Facing Point Lock.** The term plunger is sometimes applied to the handle or other operating device of a "lock-and-block" instrument.

Plunger Box. The casting or guide in which the plunger of a bridge bolt lock moves.

Plunger Casting. A stand and guide for facing point and bridge lock plungers and lock rods. See Figs. 890-909, 1580-1585, 1594-1598.

Plunger Lock. See **Facing Point Lock.** See also Figs. 890-909, 1580-1585, 1594-1598.

Pneumatic Interlocking. Interlocking apparatus in which both the power to work the switches and signals and the instrumentalities for controlling that power from the cabin are actuated by compressed air. In the older electro-pneumatic apparatus the switches and signals are worked by compressed air, but the air valves are controlled from the cabin electrically. See Figs. 1966-1977.

Point Lug. A lug bolted to the web of a switch point, to which the switch rods are attached. See Figs. 1242-1271.

Point Rail. In a "split" switch, either of the two movable rails, pointed at the movable end, as distinguished from the immovable "stock" rails.

Point Separator. A device for spacing the inner points of a double slip switch in relation to each other. Used in place of a switch point lug, which see.

Polarized Relay. A direct-current relay, having a permanently magnetized ("polarized") armature which responds to changes in the polarity of the electromagnet, resulting from changes in the direction of the current flowing in the magnet coils. Contacts carried by the polarized armature close a local circuit when the armature moves to one position under the influence of current in one direction in the magnet coils and open such circuit when current flows in the opposite direction. See Figs. 554, 2553-2555, 2568-2569, 2574-2575.

Polarized Track Circuit. See **"Wireless" Automatic Block Signal System.**

Pole Changer. A double-pole, double-throw switch so connected that the alternate positions effect a change in the direction of the current in the connecting wires. In block signaling it is attached to and worked by the home signal, for reversing the polarity of the track circuit of the section in the rear, by changing the connection from the battery to the line. This is done to control the distant signal in the rear, through the track circuit, thus obviating the need of a line wire for such control. See Figs. 416; P, Fig. 421.

Pole-Piece. That part of the core of an electromagnet which projects beyond the coil and near which the armature is placed. Often in the form of a block attached to the core. Used to concentrate the lines of force.

Polyphase Relay. A relay designed to respond to polyphase alternating current. See Figs. 496-497, 516-517, 521-522, 539.

Post. See **Signal Post; Bracket Post.**

NOTE.—Post, pole, doll, dolly, mast.—*Post,* is used to define the vertical member of a semaphore signal, because it supports something. *Pole* means a *slender* piece of timber, implying inability to support a load. *Doll* (or *dolly*) is used to define the upper vertical members of a bracket signal, particularly that one of those members which carries no arm and merely aids in making clear the position and meaning of the others. *Mast* is used in the codes of the American Railway Association to define the post (as in a bracket-post signal), to which the arm is attached, in distinction from the single post, set in the ground, supporting two or more "masts." See Figs. 189-196.

Pot Signal. A low revolving signal, turning on a vertical axis and used either as a switch target for indicating the position of the switch (to which it is attached) or as a dwarf signal for low-speed movements. Now generally superseded as a dwarf signal by the **Dwarf Semaphore,** which see. It consists of a lamp having either two or four lenses, two lenses being used for dwarf signals and four lenses for switch targets. The faces of the lamp, usually made as flaring disks, are painted corresponding colors to the lenses, and these colors give the day indications. Signals thus turning on a vertical axis are used in some tunnels and yards where there is not room for a semaphore. See **Night Signal Indications.** See Figs. 1550-1551, 1557-1559, 1568-1569, 1570-1571, 1578-1579.

Power Interlocking. Interlocking apparatus operated by some form of power other than manual, usually electricity or compressed air or a combination of the two. See **Power Interlocking Machine** and Figs. 1641-1977.

Power Interlocking Machine. An **Interlocking Machine,** which see, in which the levers for moving switches and signals by manual power are supplanted by levers, or sliding bars, for convenience, called levers, which merely close or open electric circuits, or in the all-air machine open or close air-valves. In the "electric" system the electric power moves the switches and signals. In the electro-pneumatic compressed air moves the switches and signals, and the air-valves are worked by electro-magnets controlled from the interlocking machine. See Figs. 1641-1977.

Preliminary Locking. Interlocking so arranged that the locking of a lever, to prevent it from being moved in conflict with another, which is about to be moved, is fully effected before that other lever begins to perform its function. In mechanical interlocking this is **Latch Locking,** which see. In power machines the "levers" are so arranged that the lever by a single stroke does three things: In its first part the locking of conflicting levers; in its second the performance of its own main function (causing the movement of a switch or signal), and in its third the unlocking of other levers which then may properly be moved.

Primary Battery. More properly primary cell. Any combination of two metals or metalloids, which when immersed in a liquid termed an electrolyte, and connected outside the liquid by a conductor, will produce a current of electricity. A large number of such cells employing different elements and electrolytes are in use. The action in a primary cell is electro-chemical, the electrolyte being decomposed by the passage of the current and attacking one or both of the elements. In the cell the current flows from the metal most acted on to the metal least acted on. In a zinc and copper cell with dilute sulphuric acid as the electrolyte, for example, the current flows through the liquid from the zinc to the copper. In the external circuit the direction is, of course, the opposite and the zinc

electrode is negative, while the copper electrode is positive. The most usual combinations of elements are (1) zinc and carbon and (2) zinc and copper. See **Storage Battery; Gravity Cell.**

Pulling Wire. The wire attached to the front tail lever of an interlocking machine which pulls a signal clear. See **Back Wire.**

Pusher. A locomotive used to push a train up an ascending grade, usually co-operating with another engine attached in the regular way to the front of the train. The pusher is detached at the top of the grade; and as that point may be between block stations special block-signal arrangements are sometimes prescribed to permit the pusher to back down on the same track to the point from which it began the ascent. See **Electric Train Staff System.**

Pusher Attachment. An attachment to electric train-staff apparatus, designed to protect, in addition to the regular train movement, the movement of a pushing engine when, after being detached from the rear of the train, it is to be run back to its starting point. See Figs. 301-303.

R

Radial Arm. See Figs. 1165-1184.

Rail Bond. A wire, or wires, about 2 ft. long, used to connect the adjacent ends of contiguous rails, in a track, to insure the continuity of that line of rails as an electrical conductor. Thus, in a track circuit of, say, one mile in length, each of the two lines of rails constituting that track is a conductor one mile long. In a new track the bars and bolts fastening two rails together may serve as an electrical bond, but they are not to be depended on. See Figs. 2201, 2206-2207, 2214-2225.

Rail Brace. An iron block or frame, against which the web of the rail may rest. Used to take side thrust at switches and thereby maintain the gage of the track. Usually held in place on the tie plate by lag screws or spikes and a butt strap or projection on the plate. See Figs. 918, 920-922.

Rail Clip. A metal support bolted or clamped to a rail for carrying a detector bar through suitable connections. See Figs. 955-956, 974-1002.

Railroad, Electric. See **Electric Railroad.**

Reactance. See **Inductance** and **Inductive Bond.**

Reactance Bond. See **Inductive Bond.**

Rear. As used to define signals, one which is back of another, as related to the train for which such signal is used. A distant signal is in the rear of (not in advance of) a home signal.

Rear Collision. A collision in which a train (or engine) collides with a train, car, or engine ahead of it, headed in the same direction as itself.

Rectifier. See **Mercury Arc Rectifier.**

Relay. In its most common form, an electro-magnet designed to repeat the effects of an electric current in a second circuit. For example, in a telegraph line, the relay is energized by the comparatively weak current of the line, and its armature, being thereby attracted, by suitable contacts mounted on it, closes the strong local circuit. In a track circuit, the relay, delicately adjusted to close its armature on the passage of the weak current of the track circuit, closes the strong local circuit which works or controls the signal. A relay having an armature bearing a number of contacts can be made to close as many different local circuits. When the armature of a relay is attracted, it closes a *front* contact; when the coils of the magnet are de-energized and the armature falls away by gravity or is drawn away by a spring, it closes a back contact. See Figs. 496-497, 521-522, 530-534, 539, 554, 586-598, 2553-2589. See **Interlocking Relay, Neutral Relay, Mercury Contact Relay.** For other kinds of relays see **Alternating Current Relay, Frequency Relay, Polarized Relay, Polyphase Relay, Vane Relay.**

Relay Post. A post set in the ground to support a relay box.

Repeater. See **Signal Repeater.**

Residual Magnetism. Magnetism retained in iron or steel when the magnetizing agency has been withdrawn or ceases to act. A form of permanent magnetism.

Resistance. That which opposes or resists the passage of an electric current. According to Ohm's law the ratio of the electromotive force which causes a current to flow and the current so produced or $R = \frac{E}{I}$. The unit of measurement of resistance is the **Ohm,** which see. The following table gives the relative resistance of several of the most widely used metals and of carbon, as compared with silver, the best conductor known:

Silver	1.00
Copper	1.063
Gold	1.369
Aluminum	1.935
Zinc	3.741
Platinum	6.022
Iron	6.460
Lead	13.05
German silver	13.920
Mercury	62.73
Graphite	750.00
Coke carbon	6250.00

Resistance Grid. See **Resistance.** See Figs. 528-529.

Reverse (verb). To reverse a mechanical signal lever is to move it from its normal to the opposite position. In the electro-pneumatic machine signal levers have three positions. The central position is normal and the lever is moved to the right to control one signal and to the left to control another.

Riser Plate. An iron plate riveted to the tie plate, which see, at a switch and used to support the switch points. Sometimes called a slide plate.

Rocker Shaft. See Figs. 919, 1399-1416, 1484-1488.

Rocker Shaft Leadout. See Figs. 1484-1488.

Rotor. That member of a motor or generator which revolves.

Roundel. A round, flat piece of glass, as the colored glasses used in semaphore signals.

Route. A course or way taken by a train in passing from one point to another, especially a customary or predetermined course, as in a yard; or any one of several possible combinations of turnouts or crossovers by which a train may travel from one place to another.

Route Locking. The electric locking of switches, drawbridges, etc., in a route, or the signals of a conflicting route, to maintain the integrity of a route during the moveemnt of a train over that route. Route locking may take effect upon the clearing of the signal governing the route and maintain the integrity of the route from that time until a train has passed over the route. See **Electric Locking, Track Circuit Locking.** See Figs. 1995-2016.

S

S. L. M. Abbreviation for Switch and Lock Movement.

S Armature. See **Z Armature.**

Saxby & Farmer Interlocking Machine. The most common form of mechanical interlocking machine in use in America. See Figs. 661-721.

Schedule. See **Time Table.**

Scotchblock. A block of wood or metal to be fastened on one or both rails of a track, as at the outlet of a siding or turnout, designed to throw off the track any car accidentally running from the siding to the main track when unattended or at a time when such a movement would possibly lead to a collision. See **Derail.** See Figs. 1518-1520.

Screw Jaw. A jaw fastened by a screw so as to be adjustable. See Figs. 1023-1098.

Screw Release. A device for releasing an electric lock (in a mechanical interlocking machine) which, because out of order, or by reason of some other abnormal condition, such as an error on the part of a signalman, holds locked a lever which it is desirable to move in order to avoid delaying a train. To prevent hasty action by a disturbed or excited signalman, the release is so made that it can be operated only by turning a screw a certain predetermined number of times. The release must always be restored to its original condition before normal operation of the interlocking machine can be accomplished. See Figs. 2893-2898, 2904-2908.

Secondary Battery. See **Storage Battery.**

Selector. A device whereby the position of one or more functions determines which of several others shall be operated. For example, a single merchanical lever, arranged to clear two different signals, works a pipe line which engages a connection to one or the other of those signals according as a switch is in one or the other of its two positions. This economizes levers. See **Electric Selector.** See Figs. 1482-1483.

Selector Head. See Fig. 1794.

Self-Induction. See **Inductance.**

Semaphore Bearing. The bearing which supports the semaphore casting. See Figs. 445, 2751-2768, 2800-2803.

Semaphore Casting. A casting comprising the **Arm Casting** and **Spectacle** of a semaphore signal. See Figs. 2665, 2668, 2686-2688, 2705-2709, 2717-2723, 2743-2750, 2770-2773, 3090-3092, 3094-3096.

Semaphore Shaft. The shaft which carries the semaphore casting.

Semaphore Signal. A type of signal introduced on railroads in England about 1841 and now in almost universal use for both block and interlocking signals. It consists of an arm about 4 ft. long and 10 in. wide, mounted on a post usually 24 ft. to 30 ft. high at one side of the tracks; or on a shorter post supported by a bridge or other structure above the track. Day indications are given by the position of the arm, horizontal, inclined or vertical, and night indications by a light. The pivot of the arm is combined with a spectacle casting holding colored glass disks, which, as the position of the arm is changed, move in front of a lamp mounted on the post. See **Night Signal Indications.** See Figs. 1-20, 129-141, 150-228, 248-250, 2613-2664, 2666-2667, 2670-2671, 2676-2678, 2684-2685.

Semi-Automatic Signal. A signal having both manual and track circuit control. Such a signal can be cleared by the signalman only when the track circuit is unoccupied; but it may be put in the "stop" position either manually or by the entrance of a train upon the circuit. See **Electric Slot.** See Figs. 1985-1986, 1989-1992.

Separate Pin Leadout Crank. See **Box Crank.** See Figs. 1444-1448.

Series (Electricity). Two or more pieces of electrical apparatus, such as lamps or motors, are said to be connected in series when all the current from a common source of supply flows from the supply through one lamp, thence to the next and so on to a return wire leading back to the supply. See **Multiple.**

Shackle. See Figs. 1287-1298.

Shunt (verb). Literally, to turn aside. To divert a part of an electric current by establishing for it an additional path.

Signal. A sign, agreed upon, to convey information, especially at a distance. Specifically, in railroad train-operating, a means of conveying information to the person or persons in immediate charge of the movement of a train. See the adjectives **Home, Distant, Disk, etc.** NOTE.—This book is devoted to fixed signals, as distinguished from hand-motion signals, etc.

Signal Box (British). A **Signal Cabin,** which see.

Signal Bridge. A bridge, the purpose of which is to support signals above the tracks. The signal post or disk read is mounted on the bridge. Used most frequently in yards where there is not sufficient clearance to place a post between tracks. See **Doll,** See Figs. 2667, 2671, 2676-2678.

Signal Cabin. A building, usually two-story, in which signal-operating machines are housed. The signalman's room is on the upper floor to enable him to see readily over and beyond passing trains. At a simple block station the signal levers and the telegraph instruments are the principal apparatus. At an interlocking station, where there may be from 10 to 150 or more levers the interlocking machine. (which see) may require a space from 20 ft. to 100 ft. in length. See Figs. 2970-3005.

Signalman. The attendant at a block or interlocking signal cabin. Often he has the triple function of signalman, switchman and telegraph operator, but with only this one title.

Signal Mechanism. A term used to denote the apparatus at, or within the case of, or placed upon the post of, a power-operated signal which directly operates the semaphore arm or disk of the signal. See Figs. 399-482, 501-505, 516-519, 523, 537-538, 549, 550-551, 561-564, 1700-1709, 1716-1717, 1756-1758, 1764, 1792-1793, 1857-1860, 1886, 1888, 1917-1918, 1936-1939, 1942, 1969, 1972-1979, 1983-1984, 1987-1988.

Signal Post. The upright and supporting member of a semaphore signal. It is of wood about 8 in. square (Fig. 249), or of iron, built up (Figs. 1529-1530), or of iron, tubular (Figs. 1521-1528). Frequently called **Pole.** See **Bracket Post,** Figs. 1529-1532. See **Doll.**

Signal Repeater. An indicator which shows in a cabin the changes in position of the arm or movable disk of a fixed signal. See Fig. 2040.

Slide Plate. See **Riser Plate.**

Signal Tower. See **Cabin.**

Slot. A disconnecting device inserted in the connection between a signal arm and its operating mechanism. See **Electric Slot.** In its original English form

the "slot" consists of rods having cut in them long slots. The slot is used to put a signal in the stop position, regardless of the action or inaction of the signalman in charge of such signal. With the slot arrangment a given signal can be put in the stop position by either of two signalmen, but it cannot be put in the clear position except by the co-operation of both signalmen. See Figs. 1501-1504.

Slotted Signal. A signal in which the connection from the lever or other operating mechanism is controlled by a mechanical or electric slot.

Slow-Acting Relay. A relay, the magnets of which are so designed that they retain their magnetism for an appreciable time after the circuit is interrupted, thus delaying the breaking of the circuit controlled by the relay armature.

Slow Board. A sign, usually fixed at the side of a railroad, on a board about 30 in. wide and 20 in. high, supported on a post from 4 ft. to 6 ft. high, bearing the word SLOW, or a legend indicating speed in miles per hour, to warn the enginemen of trains to reduce speed at that point. The rate of speed, if not shown, is governed by explicit instructions which are to be found in the time-table rules, and which are familiar to all of the enginemen running on the line.

Slow Releasing Slot. An electric slot for an automatic signal having a magnet so made as to consume an appreciable interval of time between the breaking of the circuit and releasing. Used instead of and made on the same principles as a slow-acting relay, which see. See Fig. 420.

Smash Signal. A signal of special form used at the approach to particularly dangerous points, such as drawbridges. Usually some form of obstruction, such as a long semaphore arm or a large disk, so arranged that when in the stop position, it fouls with the window of the locomotive cab. Where a disk is used it is commonly a plank frame suspended from a bridge over the track, and it is lowered so as to foul with the smokestack. If a train runs past the signal while it is in the stop position the "smash" will call the engineman's attention and also will leave a mark on the engine or train. The signal also will be broken, thus affording a double check on the observance of the signal.

Solenoid. A cylindrical coil of wire; a helix. Sometimes used in place of an electro-magnet. When so used an iron core is provided which enters the solenoid and is drawn in by magnetic attraction, thus performing the same function as the armature of an electro-magnet.

Solenoid Signal. See **Solenoid.** See Figs. 559-561, 1752-1764.

Sole Plate. See **Insulated Rail Joint.**

Space Interval System. The block system, as distinguished from the time interval system of regulating the movement of trains following one another. Time intervals can be maintained only at stations, and trains delayed between stations must be protected by sending a man back along the road with hand signals. As an auxiliary to this protection by flagman, fusees are thrown off from the rear of moving trains. See **Time Interval System.**

Spectacle. The casting which holds the colored glass of a semaphore signal. See **Semaphore Casting.**

Spindle Slot. An electro-mechanical slot, which see. It is attached to the semaphore shaft of a signal. See Figs. 2824-2829.

Split Link. See Figs. 1287-1298.

Split Phase. A term applied to an a.c. motor, relay or other similar apparatus that depends for its operation on a phase difference in its coils, but is operated by a single-phase current. The phase difference is obtained by "splitting" the phase of the circuit by an impedance coil or other similar device.

Squirrel Cage Armature. A term applied to a special form of rotor of an a.c. motor, consisting of an iron core, within the periphery of which are embedded a number of insulated copper conductors lying parallel to the axis of the core, their ends being united usually by copper rings or disks, so that they form closed circuits.

Staff Crane. With the electric train staff system, a post with suitable bars to support a staff, fixed near the track to enable the engineman of a train, passing at moderate speed, to reach and take a staff. Staff cranes are also made to receive a staff from a moving engine. With suitable apparatus on the engine staffs may be exchanged at high speed. See Figs. 318, 320-325.

Staff System. A method of regulating the movements of trains on a single-track railroad. A "staff," a piece of wood 22 in. long, suitably lettered, given to the engineman, is his authority, regardless of the time-table, to run his train between two sections, say A to B. At B he receives another staff for the section B-C. This system, used for many years past in Great Britain, has been generally superseded by the **Electric Train Staff,** which see.

Standard Code. The code of rules issued by the American Railway Association. It includes Train Rules, Block Signal Rules and Interlocking Rules. As issued by the Association, each of these three codes contains numerous paragraphs with words or clauses omitted, the blanks being designed to be filled up, by individual companies, to suit the practice on their respective roads. "Train rules" cover the principal features of the work of the men who operate the trains, including train despatchers and telegraph operators, and also station agents, track foremen and others, so far as their duties have to do directly with the movement of trains. This part of the code was first adopted in 1887, when few American railroads had either block signals or interlocking, and many of its rules which under that condition are of vital importance, become secondary or useless when the block system is used. As used by the railroads the "train rules" are supplemented by other train rules, usually more voluminous, dealing with the other and less important duties of trainmen.

Standard Interlocking Machine. An interlocking machine having vertical locking arranged in a frame below the surface of the floor. Locking can be arranged in two planes called front locking, which see, and back locking, which see. Originally made by The Standard Railroad Signal Company. Sometimes called "Style A" interlocking Machine. See Figs. 722-772.

Starting Signal. In Great Britain a common arrangement of signals at block stations is to have three stop signals in succession called, respectively, the home, the starting and the advanced starting signals spaced far enough apart to allow an ordinary train to stand between the first and second and between the second and third. In America the term starting signal has little recognition, officially, but it is used to designate the signals at the outer end

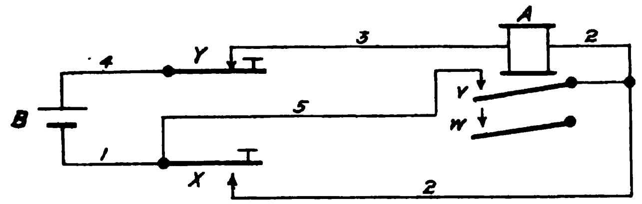
of a terminal train shed, or at the outgoing end of a side track.

Static Transformer. See **Transformer.**

Stator. That part of the electro-magnetic system of a motor or generator which is stationary.

Stevens Interlocking Machine. See Fig. 874.

Stick Relay. A relay of the ordinary type so connected that its armature closes a circuit through its own coils; that is, there are two paths provided for the current, as shown in the diagram. One path is



from battery B through wire 1, key X (when depressed), wire 2, relay coil A, wire 3, key Y, wire 4, and back to battery. This energizes the relay and closes contacts v and w. Contact v being closed, current flows from B through wires 1 and 5, contact v, wire 2, and through the coil and back to battery as before. If now key X is opened, the relay will remain energized, current still passing through its armature contact and coil. Thus to one testing the relay by means of key X it *seems* to "stick"; seems to remain closed by reason of some abnormal cause, after its circuit has been opened. When the key Y is depressed the battery is completely cut off, the relay is de-energized and the "stick" circuit is broken at v. See Figs. 1989-1990.

Stock Rail. In a "split" switch either of the two immovable rails, as distinguished from the movable "point" rails.

Storage Battery. A collection of cells or elements, consisting of two relatively inert plates of metal or metallic compounds, immersed in an electrolyte, usually dilute sulphuric acid, which is incapable of acting on them until after an electric current has passed through the liquid from one plate to another and has changed their chemical relations. When this change has been effected and the charging current ceases the cell becomes a voltaic cell capable of generating an electric current within itself and giving it off. In the simplest storage cell, that of Planté, two thin plates of lead are immersed in dilute sulphuric acid. One plate is connected to the positive pole of the charging current and the other to the negative pole. The passage of a current through the liquid decomposes it and causes the positive plate to collect on it lead peroxide PbO_2 and the negative plate to collect finely divided spongy metallic lead. When the charging current ceases the cell discharges in the opposite direction through the electrolyte. The PbO_2 gives up one of its atoms of oxygen to the spongy lead, and when the cell is fully discharged and the chemical action ceases entirely both plates are covered with PbO, lead monoxide or litharge which is inert in the electrolyte. To increase the capacity of the cell, the coating of litharge on both plates is made as great as possible by repeating the action already described; that is, by alternately reversing the direction of the charging current and the discharging current until a considerable depth of the lead plates has been acted on. This is called "forming" the plates. In modern storage batteries the lead plates are made with perforations or projections in order to increase the area of surface and to prevent the separation of the coating. These holes are filled with litharge, the active material, and the long process of forming is reduced to a single charge and discharge. Other elements have been tried besides lead, but without much commercial success.

A single cell of storage battery has an electromotive force of about 2.3 volts, falling to 1.9 volts toward the end of the discharge. The capacity or amount of current which can be stored depends on the size and character of the plates or grids. Between 80 and 90 per cent. of the electrical energy consumed in charging a cell is given off in the discharge, unless the rate of discharge is high, when the efficiency falls.

If a storage cell is short-circuited or otherwise discharged at too high a rate, the chemical action becomes violent and develops considerable heat, which will disrupt the litharge coating and warp the plates, thereby perhaps ruining the cell.

Storage batteries are coming into increasing use for power-operated signals. They may either be transported on cars to and from the charging station and the point where they are used for supplying current, or two sets of batteries may be installed at each point and one charged while the other is discharging. To do this a line wire is run from the batteries to the power house and alternately connected to the two batteries. An attendant goes over the line and throws a changing switch whenever either set of batteries is to be charged.

Stop (noun). See **Automatic Stop.**

Straight Arm Compensator. See **Compensator.** See Figs. 1107-1108, 1111-1135; D, E, F, Figs. 1149-1162.

Style "A" Interlocking Machine. A term sometimes applied to a Standard interlocking machine, which see.

Suspended Signal. A signal suspended from an overhead signal bridge, or other high structure. See Figs. 1940-1941.

Switch (noun). 1. A pair of movable track rails, with their fastenings and operating rods, providing the means for making a path over which to move an engine, car or train from one track to another. 2. A device, with a similar function, in electrical connections. Commonly a bar, pivoted at one end, which may be moved so as to touch any one of two or more contacts on as many different conductors.

Switch Adjustment. A device for reducing "overstroke" at a switch. See Figs. 923-931. See **Overstroke.**

Switch and Lock Movement. In mechanical interlocking an arrangement of rods and levers by which a single stroke of a lever performs three operations; unlocks the switch, moves it and locks it again. See Figs. 882-889, 916-917. Power-operated switch and lock movements are shown in Figs. 1671-1672, 1750, 1783-1784, 1788, 1845-1848, 1875, 1878-1884, 1889-1890, 1892-1893, 1943-1947, 1957-1960, 1966-1968.

Switchboard. A slab of slate or marble on which are mounted the necessary switches, meters and other apparatus required for regulating and controlling the electric current in a power house, sub-station or similar place. The switches and other apparatus are mounted on the front of the switchboard, and the connections and bus bars are mounted on the back. Large switchboards are usually divided into a num-

ber of separate panels. See Figs. 1770-1771, 1779, 1790, 2472, 2475-2477, 2482, 2485.

Switch Box. The familiar name for a circuit controller at a switch, which is contained in an iron box. This box is mounted on a long tie about 3 ft. from the nearest rail of the track and is connected to the point of the switch by a rod. The opening of the switch makes or breaks an electrical contact in the box. See Figs. 1751, 1765-1769, 2226-2252, 2255.

Switch Circuit Controller. See **Switch Box; Electric Selector.**

Switch Indicator. A device to indicate visually or audibly, or both, to the person moving an isolated switch, whether or not a train has entered or is approaching the block in which the switch is situated, and if it is permissible to open the switch. Used principally in connection with automatic block signals. The visual indicator consists of a pair of magnets and an armature, to which is attached a small movable disk or miniature semaphore arm. The whole apparatus is enclosed in a weatherproof case, having a glass front, which is mounted on a post near the switch stand. The magnet coils are energized by a line-wire circuit which extends back at least two full block sections, and which passes through normally closed contacts on all the intervening track relays or through normally closed contacts on the home signal arms. When this circuit is broken by the presence of a train anywhere within the limits of the circuit, which would open one or more contacts, the armature drops and moves the disk or semaphore arm into the position, indicating the approach of a train and giving warning against opening the switch. The audible warning is given by a vibrating bell connected through a similar circuit. The bell, however, is usually arranged to ring only when a train is approaching the block and is cut out as the train enters the block. The line-wire circuit for both the audible and the visual indicator is carried back far enough, so that warning of the approach of a train will be given at the switch before the train comes in sight of the distant signal controlled by the first home signal in the rear of the switch. See Figs. 2830-2865.

Switch Instrument. See **Switch Box** and **Electric Selector.**

Switch Lock, Electric. See **Electric Switch Lock.**

Switch Rod. See **Switch.**

Switch Tender. A person who tends switches. Applied to attendants of ground switches, which usually are not interlocked. The attendant in an interlocking cabin moves and controls switches, as well as signals, but his designation is signalman.

Sykes' Lock and Block Instrument. The controlled manual block signal apparatus invented by W. R. Sykes in England, and the first used in America. A few Sykes' instruments were installed on the New York Central as early as 1882, but these have since been replaced by later designs. The Coleman machine embodies all of the features of the Sykes machine and a number of additional safeguards. The Sykes system, as used on the New York Central, was applicable only to double-track roads, since the release is accomplished while a train is passing over a short releasing track circuit, which in the case of a single-track road would release the machine ahead of the train as well as in the rear and might result in allowing two trains moving in opposite directions to enter the block at opposite ends at the same time. See **Controlled Manual Block System.**

Synchronism. A simultaneous occurrence of any two events. An a.c. motor is said to be synchronous when its rotor revolves at the same speed as the rotor of the generator. A synchronous motor is said to be in step with the generator.

Synchronous Motor. See **Synchronism.**

T

Table Lever. A lever for working a block signal very near the office, fixed in the telegraph operator's table. See Figs. 240-247.

Tail Lever. The arm of the lever of an interlocking machine, to which the operating pipe or wire is connected. See **Interlocking Machine.**

Tang End. A projection on the end of a jaw or rod one-half the length of a pipe plug, used to stiffen the joint between the pipe line and the jaw or rod in the same manner as the pipe plug, which see. See Figs. 1008-1013.

Tappet. 1. (In an interlocking machine with vertical locking.) A bar operated directly or indirectly by the lever or lever latch, which actuates or drives the locking bars and is locked by them. 2. (In an interlocking machine with horizontal locking.) A pivot or swing dog attached to the locking bar and actuated or locked by the cross-locking. See **Interlocking Machine.**

Telegraph. See **Telegraph Block System, Manual Block System, Controlled Manual Block System, Needle Telegraph, Morse Telegraph.** See Figs. 2882-2885.

Telegraph Block System. "A series of consecutive blocks controlled by block signals operated manually upon information by telegraph" (A. R. A.) Another name for the **Manual Block System,** which see. The American Railway Association has adopted this term (as above), although it is not strictly confined to a system in which the telegraph is the means of communication between block stations, bells or telephones being used in some cases.

Telephone. Apparatus by which sounds (of the human voice) are repeated at a distance. Used as a means of communication. See **Manual Block System; Controlled Manual Block System; Telegraph Block System.** See Figs. 2886-2888.

Terminal Board. A collection of binding posts mounted on a slab or board to which the ends of a number of wires may be attached and interconnected, as desired, by short pieces of wire or metal strips called jumpers.

Thomas Interlocking. A system of pneumatic interlocking using compressed air only at a pressure of 80 lbs. per sq. in. It depends for its operation on a difference of pressure of 10 lbs. between the pipes, both in working a function and obtaining the indication. This system was invented by J. W. Thomas, Jr., and originally installed at Nashville on the Nashville, Chattanooga & St. Louis.

Threaded Rod. A term sometimes applied to a throw rod, which see.

Three-Position Signal. A semaphore signal arranged to give three different indications. See Figs. 136-141, 165-176. In a common form (manually operated) the horizontal position of the arm indicates "stop," the arm inclined downward 37½ deg. "caution" (permissive block signaling) and inclined downward about 75 deg. "proceed" (speed not limited). On a few roads the arrangement is horizontal "stop"; upward 45 deg., "caution"; downward, 45 deg., "proceed" (speed not limited). In automatic three-position signals (which see) and

in some manual signals the proceed position is vertical (90 deg. from horizontal), but the arm is made to stand clear of the post, so that the engineman may see that it is not missing.

Three-Position Automatic Block Signals. A system of automatic block signals designed to provide the protection of distant signals without the duplication of signal arms usually involved. Each signal arm is so arranged that it may be put in any one of three positions; horizontal for stop; inclined 45 deg. for "caution" and vertical for proceed. The signal goes to the stop position when a train enters the block; when the train has cleared the block it moves to the caution position, and it remains in that position until the next signal in advance moves to the caution position, when it goes to "clear." A train is thus always protected by a stop signal in the rear and a caution signal one block further back. Three-position automatic block signals were first introduced on the Pennsylvania Lines West of Pittsburgh in the year 1900.

Throw Rod. The rod connecting a switch to its operating mechanism. The throw rod is connected to the head rod of the switch by a switch adjustment, which see. See also Figs. 923-931.

Tie Plate. In interlocking work, an iron plate fastened to the upper surface of a tie or sleeper and extending across the track beneath the rails. Used principally at switches and movable point frogs in connection with rail braces, butt straps and slide plates, to hold the track to gage. See Figs. 918, 1690-1691.

Tie Strap. A flat iron rod or bar, fastened by spikes or lag screws to the ties (as at a switch) to hold the ties in position. See Fig. 918.

Tie Wire. A short piece of wire used to tie line wires to insulators. See Figs. 2452-2455.

Time-Interval System. The rules under which trains are run where there is no block system. To obviate the danger of rear collisions in consequence of unexpected delays to trains between stations the attendant at each station sees that a prescribed interval, usually five, seven or ten minutes, is maintained between trains. This interval is intended to allow time enough for the protection of a delayed train by sending back a flagman to warn any following train. At night the flagman carries a red lantern. Both night and day he carries torpedoes with which to give audible signals, and fusees, which see.

Time Lock. A device similar in purpose to a time release. It is usually automatic in action. See **Time Release.** See Figs. 2889-2892, 2909-2910.

Time Release. A device for releasing an electric lock (on a signal or other lever) when it remains locked because of abnormal conditions and thereby delays traffic. See **Screw Release.** See Figs. 2893-2910.

Time-Table. The statement of stations, trains and times, issued by the superintendent of a railroad for the guidance of the men in charge of trains. It is the authority for the movement of regular trains. A *schedule*—one column in a time-table—prescribes the class, direction, number and movement of a regular train, showing where and when it begins its trip and the time at each station. On a single-track railroad the rules regulating meeting points are a vital element of the time-table; but where the block system is used these and many other time-table rules become of minor importance, as provisions for safety, though they still remain important as matters of convenience. Time-tables contain *local* or temporary rules modifying the general train rules contained in the Standard Code of Rules.

Tommy Bar. See Fig. 2911.

Torpedo. An explosive cap, the size of a small watch, to be fastened on the top of a rail of the track, to be exploded by the pressure of the first wheel of an approaching engine or train. The detonation indicates "stop." Torpedoes are used when, by reason of fog, snow or darkness, a visible stop signal may not be seen by the engineman. See Figs. 2960-2969, 3119-3120.

Torpedo Placer. An apparatus for putting torpedoes in position to be exploded by the passage of a wheel of a locomotive or other vehicle. In the design shown in Figs. 2964-2969 the torpedo lies beneath an anvil which is at the side of the rail and is depressed by the outer part of the tread of a wheel. The apparatus shown in Figs. 2960-2963 (Zorge's) is automatic, worked by an electric motor. The motor, when energized (in conjunction with the movement of a visual block signal to the stop or caution position) moves a pair of torpedoes into position on the head of the rail. The torpedoes are carried on a fragile iron bar, which is broken if the torpedo is exploded. The motor is arranged to withdraw the torpedoes if the block section is cleared before they are used. On British railroads where torpedoes are usually placed by hand by attendants (in times of fog) a hand placing-apparatus is sometimes used, to relieve the attendant from the dangerous duty of crossing tracks, as is necessary in the case of a four-track line.

Torque. That moment of the force applied to a generator, motor or other machine which turns it or causes its rotation. The mechanical rotary or turning force which acts on the armature of a generator, motor or other machine and causes it to rotate. In the case of the rotor of a generator or motor the torque is equal to the radius of the armature multiplied by the pull at the circumference, or the radius of its pulley multiplied by the pull at the circumference of the pulley. A torque is exerted on the shaft of a motor from the electromagnetic action or pull at the periphery of the armature. The torque is usually measured in pounds of pull at the end of a radius or arm 1 ft. in length.

Toucey & Buchanan Interlocking. One of the earliest American interlocking machines. Used on the New York Central; now superseded.

Tower. The common name for a signal cabin, which usually is high in proportion to the ground area. See **Cabin.**

Track Bond. See **Rail Bond.**

Track Circuit. An electric current flowing through the rails of a railroad track. In a typical track circuit, Fig. 326, the current flows from the battery to the nearest rail of the track, thence to the other end of the track circuit section; thence by wire to the track relay (controlling a signal) back by a wire to the farther rail, and by that rail back to the battery. Each rail is made electrically continuous from one end of the track-circuit section to the other by metallic bonds at the joints, and at the ends of the section insulated joints are used. See **Rail Bond; Insulated Rail Joint.**

Track Circuit Locking; Electric Locking, which see, accomplished by track circuits.

Track Instrument. A lever fixed to a tie, to be moved by the weight of the wheels of a passing train, or by deflection of a rail under the weight of the wheels, and designed to open or close an electrical contact in an electric circuit. Used to control circuits for highway crossing bells, annunciators, etc. In automatic block signaling without track circuits (formerly in use in New England) two such instruments are required for each signal, one at the entrance to the block, in which the contact is normally closed and is opened, by the passage of a train, to move the signal to the stop position, and the other, at the outgoing end of the block, in which the contact is normally open and is closed, by the passage of the train, to restore the signal to the clear position. The two instruments are connected with the signal mechanism by wire strung on poles. Wire-circuit signals were used as early as 1871, but are now obsolete, having been generally superseded by **Track Circuit Signals.** See Figs. 2272-2273, 2281.

Track Model. In an interlocking machine, a map-like miniature reproduction (with movable pieces representing the switches) of the tracks in which are the switches controlled by the machine. See Figs. 1897, 1901-1902. Following each movement of a switch, the attendant, who has moved the lever, sees the effect of his action repeated on the model.

Track Indicator. A map-like reproduction of railroad tracks, made on transparent glass, with electric lights, controlled by track circuits so arranged beneath the glass as to indicate automatically, for defined sections of track, by distinctive colors, whether or not such sections are occupied by a vehicle or vehicles. Used principally at interlocking plants. See Figs. 2055-2062.

Track Relay. A relay in a track circuit. See **Relay.**

Traffic, Maximum, on a Block Signal Line. See **Block Signaling for Maximum Traffic.**

Traffic Lever. A **Check Lock Lever,** which see.

Trailing Point Switch. The opposite for **Facing Point Switch,** which see.

Train Describer. An electrical instrument designed to give information regarding the origin, destination, class or character of trains, engines or cars moving or to be moved between defined points. Used in signal cabins to announce trains from one cabin to another, or from train sheds to cabins or despatchers' offices. See Figs. 2032-2033.

Train Despatcher. The officer who supervises the movement of the trains on a given division of railroad, sending telegraphic orders to the conductors and enginemen of trains for which the time-table does not give full authority. On a single-track line he must by this means adjust the relative rights of opposing regular trains when one or both is behind time and those of all extra trains.

Train-Order Signal. A fixed signal—semaphore or other—used at telegraph offices to indicate to a train that it must stop there to receive a telegraphic order affecting its right to the road.

Train Staff. See **Staff System; Electric Train Staff system.**

Train Stop. See **Automatic Stop.**

Transformer. A device for transforming an alternating current of high voltage into an alternating current of the same frequency, but of lower voltage, and greater amperage or vice versa. A transformer which reduces the voltage is a step-down transformer; one which increases the voltage is a step-up transformer. The usual form consists of two separate coils of wire wound on a soft iron core. The coil carrying the impressed current is the primary and the other is the secondary. The action in the transformer is entirely inductive, the current flowing in the primary coil inducing magnetic lines of force in the core, which in turn induce a current in the secondary coil. The voltage in the primary and secondary coils vary approximately with the number of turns of wire in each and the current inversely as the number of turns. Thus, with 500 turns in the primary and 100 turns in the secondary the reduction in voltage would be 5 to 1 and the increase in current would be as 1 to 5. See Figs. 488-491, 512, 526.

Transverse Pipe Carrier. A pipe carrier designed to guide pipe across tracks; usually supported on ties; sometimes called a hanging pipe carrier. See **Pipe Carrier.** See Figs. 1163-1164, and G, H, K, L, N, Figs. 1213-1241.

Trunking. The wooden casing used to protect from snow and from mechanical injury wires, both electrical conductors and those used to pull signal arms when they lie on or near the surface of the ground. See Figs. 3012-3023, 3036.

Tunnel Signal. A signal designed to be placed in a tunnel. It gives indications usually wholly by colored lights. Sometimes called a light signal. A **Pot Signal,** which see, is sometimes used as a tunnel signal. See Figs. 506-508, 516-519, 535, 537-538, 540-541, 543-545, 558, 562-564, 1953.

Two-Light Signal Aspects (system of). An arrangement of semaphore signals, in which every signal shows, at night, at least two lights, as, for example, at a signal where there is a main route and one diverging route. At a block signal where no diverging route is to be signaled the second or lower light (never indicating proceed) is of use to assist the engineman in quickly reading the upper one. A second arm may be used as well as a second light, so as to give the desired aspect in daylight as well as at night. See Figs. 165-176.

U

Unit, Interlocking. See **Function.**

Up-and-Down Rod. The common name for the movable vertical rod connecting a semaphore signal arm with the operating mechanism at the base of the signal post.

Upper Quadrant. One of the quarters of a circle above its horizontal axis; a term used of semaphore signals, in which the arm, normally horizontal (indicating stop) is turned upward to give other than stop indications.

V

Vane Relay. A type of alternating current relay in which a light metal disk, or vane, perforated with radial slots, is caused to move between the pole pieces of magnets to close contacts when the magnets are energized, or open them through the falling of the vane by gravity, when the magnets are de-energized. See Figs. 530-534.

Vertical Locking. Mechanical locking arranged in a vertical plane. See **"Standard," National** and **Johnson Interlocking Machines.**

Volt. The practical unit of measurement of electro-motive force. Such an electro-motive force as will cause a current of one ampere to flow through a circuit with a resistance of one ohm. See **Ampere.**

Voltmeter. An instrument for measuring, in terms of volts, the electro-motive force of a current of electricity. It is similar in principle and construction to the **Ammeter,** which see, but the coil is wound with many turns of fine wire so as to work with very small currents and a resistance of several thousand ohms is usually placed in series with it. See Figs. 2913, 2926, 2930-2931, 2933, 2934, 2946, 2951, 2952, 2954.

W

Watt. The unit of electric power. The product of volts times amperes. One horse-power is equal to 746 watts.

Watt Hour. The unit of electric work, representing the expenditure of one watt for one hour.

Watt Meter. An instrument for measuring the power of an electric current passing through any circuit. It is provided with two sets of coils. One is a current coil and the other, suspended inside the first, is free to turn. This measures the voltage of the current passing. The torque produced, tending to displace the revolving coil, is proportional to the product of the magnetic fields developed by the fixed and the movable coil and therefore is proportional to the energy or electrical power passing in the circuit. The amount of the displacement is read by a pointer on a graduated scale.

The more usual form is the integrating watt meter which records on a series of dials, the number of watt hours of power consumed. The Thompson integrating watt meter, which is the best-known type, is essentially a small motor, the speed of which is proportional to the power in the circuit. The entire current flows through the field coils, which are wound with heavy wire. The armature, which is wound with very fine wire, is in series with a very large resistance placed across the mains. The armature shaft carries a copper disk, revolving between the poles of three drag magnets, which produce a constant retarding force. The other end of the armature shaft carries a worm to drive the recording gear. Such a meter will register within 2 per cent. for long periods without adjustment.

Well. A cylindrical hole in the ground, usually lined with concrete or masonry, or containing a wooden tub, used to keep batteries protected from frost. See Figs. 2160-2171, 2188-2189.

Wheel. See **Chain Wheel.**

Wide Jaw. See Figs. 1023-1098.

Wire (Electric Conductors). For telegraph lines galvanized iron wire of size 8 or 9, B. W. G., is in extensive use. Copper wire of size 10, 12 or 14, B. & S., is also much used. Line wires used in automatic block signaling are of size 10, 12 or 14, B. & S., but a "common wire" serving as the return portion of a number of circuits is usually larger. All of these are sometimes covered with a continuous insulating covering. Wires inside of buildings and those connecting instruments and lines to the rails of the track are of copper, insulated. See **Cable, Copper-Clad Wire, Insulated Wire, Kerite, Okonite.** See Figs. 3065-3074.

Wire Carrier. A roller or pulley supported in a frame, used as a support and guide for a wire line. See Figs. 1304-1330.

Wire, Conductivity. See **Wire, Sizes of.**

Wire Gage. See **Wire, Sizes of.**

Wire Eye. See Figs. 1285-1286.

Wire, Sizes of. The diameters and weights of the different sizes of wire, according to the Birmingham and the Brown & Sharpe wire gages, with other information are given in the accompanying tables:

TABLE OF DIMENSIONS, WEIGHT, AND RESISTANCE OF COPPER WIRE.
(Birmingham Gauge.)

Gauge Number.	Diameter, Inch.	Sectional Area in Circular Mils. = diam².	Weight.		Length.		Resistance.		Gauge Number.
			Lbs. per Foot.	Lbs. per Ohm.	Feet per Lb.	Feet per Ohm.	Ohms per Lb.	Ohms per Foot.	
0000	.454	206116	.623925	12486.73	1.6027	19966.55	.00008027	.000050084	0000
000	.425	180625	.54676	9569.13	1.8285	17496.15	.00010450	.000057152	000
00	.38	144400	.437107	6256.59	2.2878	13988.	.00015983	.000071490	00
0.	.34	115600	.349928	3918.60	2.8577	11198.17	.00025528	.0000893	0
1	.3	90000	.272435	2375.17	3.6706	8718.3	.00042102	.000114701	1
2	.284	80656	.24415	1952.03	4.0958	7813.15	.00051229	.00012799	2
3	.259	67081	.202964	1318.28	4.927	6495.15	.00075857	.00015396	3
4	.238	56644	.171465	940.862	5.832	5487.11	.00106285	.000182665	4
5	.22	48400	.14651	688.494	6.8255	4688.51	.00145245	.000212795	5
6	.203	41209	.124742	497.631	8.0165	3989.26	.00200929	.00025067	6
7	.18	32400	.098076	307.82	10.1962	3138.59	.00324866	.000318615	7
8	.165	27225	.08241	217.338	12.1345	2637.29	.00460113	.000379178	8
9	.148	21904	.066305	140.754	15.0818	2122.82	.0071046	.000471073	9
10	.134	17956	.054354	94.5433	18.3979	1739.4	.0105772	.00057491	10
11	.12	14400	.04359	60.805	22.941	1394.53	.012446	.00071688	11
12	.109	11881	.035964	43.3914	27.8056	1150.91	.0241596	.000868875	12
13	.095	9025	.027319	23.8837	36.6046	874.252	.0418696	.00114384	13
14	.083	6889	.020853	14.9849	47.9547	667.338	.0718596	.0014985	14
15	.072	5184	.015692	7.88012	63.7267	502.21	.126902	.00199134	15
16	.065	4225	.012789	5.23433	78.1922	409.276	.19105	.00244334	16
17	.058	3364	.01018	3.31726	98.232	325.87	.30144	.0030687	17
18	.049	2401	.007268	1.69043	137.586	232.585	.591566	.0042995	18
19	.042	1764	.005340	.912492	187.266	170.879	1.0959	.0058521	19
20	.035	1225	.003708	.44013	269.687	118.666	2.27266	.008427	20
21	.032	1024	.003099	.307405	322.585	99.195	3.25304	.010087	21
22	.028	784	.002373	.18022	421.407	75.946	5.54876	.0131672	22
23	.025	625	.001892	.114549	528.54	60.5438	8.7299	.016517	23
24	.022	484	.001465	.0686867	682.594	49.885	14.5589	.0213287	24
25	.020	400	.001211	.046924	825.764	38.748	21.3111	.0258078	25
26	.018	324	.0009807	.030786	1019.68	31.386	32.4885	.0318615	26
27	.016	256	.0007749	.0192165	1290.489	24.7987	52.0389	.0403246	27
28	.014	196	.0005933	.0112647	1685.488	18.9866	88.773	.052668	28
29	.013	169	.0005116	.00837544	1954.652	16.371	119.397	.061083	29
30	.012	144	.0004359	.00608035	2294.104	13.949	164.46	.071688	30
31	.01	100	.0003027	.00293266	3303.60	9.687	341.034	.103231	31
32	.009	81	.0002452	.00192595	4078.303	7.8465	519.763	.127446	32
33	.008	64	.0001937	.0012013	5160.78	6.1998	832.426	.1613	33
34	.007	49	.0001483	.000703925	6743.088	4.7466	1420.6	.21068	34
35	.005	25	.00007568	.000183269	13214.16	2.4217	5456.5	.41293	35
36	.004	16	.00004843	.000074894	20647.12	1.5499	13321.406	.6452	36

From Kent's Mechanical Engineer's Pocket Book.

DIMENSIONS, WEIGHT, AND RESISTANCE OF COPPER WIRE.
(Brown & Sharpe's Gauge.)

Gauge Number.	Diameter Inch.	Sect. Area in Circular Mils.	Weight. Lbs. per Foot.	Weight. Lbs. per Ohm.	Length.—Feet. Per Lb.	Length.—Feet. Per Ohm.	Resistance.—Ohms. Per Foot.	Resistance.—Ohms. Per Lb.	Gauge Number.
0000	.46	211600.	.640525	13129.29	1.56122	20497.7	.000048786	.0000761656	0000
000	.40964	167805.	.507955	8256.95	1.9687	16255.27	.000061519	.00012111	000
00	.3648	133079.	.40284	5193.13	2.4824	12891.37	.0000775713	.000192562	00
0	.32486	105534.	.319457	3265.84	3.1303	10223.08	.000097818	.0003062	0
1	.2893	83694.	.253348	2054.015	3.94714	8107.49	.000123342	.000476866	1
2	.25763	66373.	.200915	1291.80	4.97722	6429.58	.00015553	.000774113	2
3	.22942	52634.	.159325	812.709	6.2765	5098.61	.000196132	.00123102	3
4	.20431	41743.	.126357	522.839	7.9141	4043.6	.000247304	.00191263	4
5	.18194	33102.	.10022	321.309	9.97983	3206.61	.000311856	.00311227	5
6	.16202	26251.	.0794616	202.062	12.5847	2542.89	.000393256	.00494898	6
7	.14428	20817.	.0630134	127.07	15.8696	2015.51	.000495905	.00785156	7
8	.12849	16510.	.0499757	79.9258	20.0097	1599.3	.000625276	.0125116	8
9	.11443	13094.	.039637	50.2886	25.229	1268.44	.00078837	.0198852	9
10	.10189	10382.	.0314256	31.6036	31.8212	1055.66	.00099437	.031642	10
11	.090742	8234.	.024925	19.882	40.1202	797.649	.0012537	.0502987	11
12	.080808	6530.	.0197665	12.5034	50.5906	632.555	0015809	.0799783	12
13	.071961	5178.	.0156753	7.86319	63.7948	501.63	.0019935	.127172	13
14	.064084	4107.	.0124314	4.51033	80.4415	397.822	.0025137	.221713	14
15	.057068	3257.	.0098584	3.11015	101.4365	315.482	.00316975	.321528	15
16	.05082	2583.	.0078179	1.95501	127.12	250.184	.00399707	.511507	16
17	.045257	2048.	.0062	1.23013	161.29	198.409	.0050401	.812918	17
18	.040303	1624.	.004917	.773677	203.374	157.35	.0063553	1.29253	18
19	.03589	1288.	.0038991	.486524	256.468	124.777	.00801426	2.0554	19
20	.031961	1021.	.0030922	.305979	323.399	98.9533	.0101058	3.2682	20
21	.028462	810.	.0024522	.192429	407.815	78.473	.0127432	5.19671	21
22	.025347	642.	.0019448	.121037	514.193	62.236	.0160678	8.26197	22
23	.022571	509.	.0015421	.076105	648.452	49.3504	.0202633	13.13974	23
24	.0201	404.	.001223	.0478624	817.688	39.1365	.0255516	20.89323	24
25	.0179	320.	.0009699	.0301038	1031.038	31.0381	.0322184	33.2184	25
26	.01594	254.	.0007691	.0168719	1300.180	24.6131	.0406288	53.8247	26
27	.014195	201.	.0006099	.0119056	1639.49	19.5191	.0512318	83.994	27
28	.012641	159.8	.0004837	.0074748	2067.364	15.4793	.0646023	133.5563	28
29	.011257	126.7	.0003836	.0047087	2606.959	12.2854	.081464	212.373	29
30	.010025	100.5	.0003042	.00296174	3287.084	9.7355	.102717	337.639	30
31	.008928	79.7	.0002413	.0018306	4414.49	7.72143	.12951	536.7515	31
32	.00795	63.	.0001913	.00117133	5226.915	6.12243	.163334	853.732	32
33	.00708	50.1	.0001517	.000736789	6590.41	4.85575	.205942	1357.241	33
34	.006304	39.74	.0001203	.0004631	8312.8	3.84966	.25976	2159.361	34
35	.005614	31.5	.0000954	.000291272	10481.77	3.05305	.327541	3433.21	35
36	.005	25.	.00007568	.000183269	13214.16	2.4217	.41293	5456.45	36
37	.004453	19.8	.00006003	.000115298	16659.97	1.92086	.520601	8673.2	37
38	.003965	15.72	.00004759	.0000724741	21013.25	1.52292	.656635	13798.04	38
39	.003531	12.47	.00003774	.0000455828	26496.237	1.20777	.82797	21938.11	39
40	.003144	9.88	.00002992	.0000369803	33420.63	0.97984	1.04435	27041.4	40

SIZE, WEIGHT, LENGTH, AND STRENGTH OF IRON WIRE.
(Trenton Iron Co.)

No. by Wire Gauge.	Diam. in Decimals of One Inch.	Area of Section in Decimals of One Inch.	Feet to the Pound.	Weight of One Mile in pounds.	Tensile Strength (Approximate) of Charcoal Iron Wire in Pounds. Bright.	Tensile Strength (Approximate) of Charcoal Iron Wire in Pounds. Annealed.
00000	.450	.15904	1.863	2833.248	12598	9449
0000	.400	.12566	2.358	2238.878	9955	7466
000	.360	.10179	2.911	1813.574	8124	6091
00	.330	.08553	3.465	1523.861	6880	5160
0	.305	.07306	4.057	1301.678	5926	4445
1	.285	.06379	4.645	1136.678	5226	3920
2	.265	.05515	5.374	982.555	4570	3425
3	.245	.04714	6.286	839.942	3948	2960
4	.225	.03976	7.454	708.365	3374	2530
5	.205	.03301	8.976	588.139	2839	2130
6	.190	.02835	10.453	505.084	2476	1860
7	.175	.02405	12.322	428.472	2136	1600
8	.160	.02011	14.736	358.3008	1818	1360
9	.145	.01651	17.950	294.1488	1507	1130
10	.130	.01327	22.333	236.4384	1233	925
11	.1175	.01084	27.340	193.1424	1010	758
12	.105	.00866	34.219	154.2816	810	607
13	.0925	.00672	44.092	119.7504	631	473
14	.080	.00503	58.916	89.6016	474	356
15	.070	.00385	76.984	68.5872	372	280
16	.061	.00292	101.488	52.0080	292	220
17	.0525	.00216	137.174	38.4912	222	165
18	.045	.00159	186.335	28.3378	169	127
19	.040	.0012566	235.084	22.3872	137	103
20	.035	.0009621	308.079	17.1389	107	80
21	.031	.0007547	392.772	13.4429		
22	.028	.0006157	481.234	10.9718		
23	.025	.0004909	603.863	8.7437		
24	.0225	.0003976	745.710	7.0805		
25	.020	.0003142	943.396	5.5968		
26	.018	.0002545	1164.689	4.5334		
27	.017	.0002270	1305.670	4.0439		
28	.016	.0002011	1476.869	3.5819		
29	.015	.0001767	1676.989	3.1485		
30	.014	.0001539	1925.321	2.7424		
31	.013	.0001327	2232.653	2.3649		
32	.012	.0001131	2620.607	2.0148		
33	.011	.0000950	3119.092	1.6928		
34	.010	.00007854	3773.584	1.3992		
35	.0095	.00007088	4182.508	1.2624		
36	.009	.00006362	4657.728	1.1336		
37	.0085	.00005675	5222.035	1.0111		
38	.008	.00005027	5896.147	.89549		
39	.0075	.00004418	6724.291	.78672		
40	.007	.00003848	7698.253	.68587		

The above figures on tensile strength are based upon tests made with good charcoal-iron wire from Trenton blooms. The tensile strength of wire made of—
Good refined iron is about 15% less.
Swedish charcoal iron is about 10 " "
Mild Bessemer steel is about 10 % more.
Ordinary crucible steel is about 25 " "
Special crucible steel is from 50 to 120 " "
than that of charcoal-iron wire.

WIRE AND SHEET-METAL GAUGES COMPARED.

Number of Gauge.	Birmingham (or Stubs' Iron) Wire Gauge. inch.	American or Brown and Sharpe Gauge. inch.	Roebling's and Washburn & Moen's Gauge. inch.	Stubs' Steel Wire Gauge. inch.	British Imperial Standard Wire Gauge. (Legal Standard in Great Britain since March 1, 1884.) inch.	British Imperial Standard Wire Gauge. millim.	U. S. Standard Gauge for Sheet and Plate Iron and Steel. (Legal Standard since July 1, 1893.) inch.	Number of Gauge.
0000000			.49		.500	12.7	.5	7/0
000000			.46		.464	11.78	.469	6/0
00000			.43		.432	10.97	.438	5/0
0000	.454	.46	.393		.4	10.16	.406	4/0
000	.425	.40964	.362		.372	9.45	.375	3/0
00	.38	.3648	.331		.348	8.84	.344	2/0
0	.34	.32486	.307		.324	8.23	.313	0
1	.3	.2893	.283	.227	.3	7.62	.281	1
2	.284	.25763	.263	.219	.276	7.01	.266	2
3	.259	.22942	.244	.212	.252	6.4	.25	3
4	.238	.20431	.225	.207	.232	5.89	.234	4
5	.22	.18194	.207	.204	.212	5.38	.219	5
6	.203	.16202	.192	.201	.192	4.88	.203	6
7	.18	.14428	.177	.199	.176	4.47	.188	7
8	.165	.12849	.162	.197	.16	4.06	.172	8
9	.148	.11443	.148	.194	.144	3.66	.156	9
10	.134	.10189	.135	.191	.128	3.25	.141	10
11	.12	.09074	.12	.188	.116	2.95	.125	11
12	.109	.08081	.105	.185	.104	2.64	.109	12
13	.095	.07196	.092	.182	.092	2.34	.094	13
14	.083	.06408	.08	.180	.08	2.03	.078	14
15	.072	.05707	.072	.178	.072	1.83	.07	15
16	.065	.05082	.063	.175	.064	1.63	.0625	16
17	.058	.04526	.054	.172	.056	1.42	.0563	17
18	.049	.0403	.047	.168	.048	1.22	.05	18
19	.042	.03589	.041	.164	.04	1.02	.0438	19
20	.035	.03196	.035	.161	.036	.91	.0375	20
21	.032	.02846	.032	.157	.032	.81	.0344	21
22	.028	.02535	.028	.155	.028	.71	.0313	22
23	.025	.02257	.025	.153	.024	.61	.0281	23
24	.022	.0201	.023	.151	.022	.56	.025	24
25	.02	.0179	.02	.148	.02	.51	.0219	25
26	.018	.01594	.018	.146	.018	.46	.0188	26
27	.016	.01419	.017	.143	.0164	.42	.0172	27
28	.014	.01264	.016	.139	.0148	.38	.0156	28
29	.013	.01126	.015	.134	.0136	.35	.0141	29
30	.012	.01003	.014	.127	.0124	.31	.0125	30
31	.01	.00893	.0135	.120	.0116	.29	.0109	31
32	.009	.00795	.013	.115	.0108	.27	.0101	32
33	.008	.00708	.011	.112	.01	.25	.0094	33
34	.007	.0063	.01	.110	.0092	.23	.0086	34
35	.005	.00561	.0095	.108	.0084	.21	.0078	35
36	004	.005	.009	.106	.0076	.19	.007	36
37		.00445	.0085	.103	.0068	.17	.0066	37
38		.00396	.008	.101	.006	.15	.0063	38
39		.00353	.0075	.099	.0052	.13		39
40		.00314	.007	.097	.0048	.12		40
41				.095	.0044	.11		41
42				.092	.004	.10		42
43				.088	.0036	.09		43
44				.085	.0032	.08		44
45				.081	.0028	.07		45
46				.079	.0024	.06		46
47				.077	.002	.05		47
48				.075	.0016	.04		48
49				.072	.0012	.03		49
50				.069	.001	.025		50

INSULATED COPPER WIRE, WEATHERPROOF INSULATION.

Numbers, B. & S. Gauge.	Double Braid.			Triple Braid.			Approximate Weights, Pounds.	
	Outside Diameters in 32ds Inch.	Weights, Pounds. 1000 Feet.	Weights, Pounds. Mile.	Outside Diameters in 32ds Inch.	Weights, Pounds. 1000 Feet.	Weights, Pounds. Mile.	Reel.	Coil.
0000	20	716	3781	24	775	4092	2000	250
000	18	575	3036	22	630	3326	2000	250
00	17	465	2455	18	490	2587	500	250
0	16	375	1980	17	400	2112	500	250
1	15	285	1505	16	306	1616	500	250
2	14	245	1294	15	268	1415	500	250
3	13	190	1003	14	210	1109	500	250
4	11	152	808	12	164	866	250	125
5	10	120	634	11	145	766	260	130
6	9	98	518	10	112	591	275	140
8	8	66	349	9	78	412	200	100
10	7	45	238	8	55	290	200	100
12	6	30	158	7	35	185	....	25
14	5	20	106	6	26	137	....	25
16	4	14	74	5	20	106	....	25
18	3	10	53	4	16		....	25

From Kent's Mechanical Engineer's Pocket Book. Copyright, 1902, by William Kent.

HARD-DRAWN COPPER TELEGRAPH WIRE.
(J. A. Roebling's Sons Co.)

Size, B. & S. Gauge.	Resistance in Ohms per Mile.	Breaking Strength.	Weight per Mile.	Approximate Size of E. B. B. Iron Wire equal to Copper. Iron-Wire Gauge
9	4.30	625	209	2
10	5.40	525	166	3
11	6.90	420	131	4
12	8.70	330	104	6
13	10.90	270	83	6½
14	13.70	213	66	8
15	17.40	170	52	9
16	22.10	130	41	10

From Kent's Mechanical Engineer's Pocket Book. Copyright, 1902, by William Kent.

Wire, Signal. In manually operated semaphore signals, the wire, usually of steel, about No. 8 or No. 9, B. W. G., connecting a signal arm with its lever in the cabin. It is supported on wire carriers fixed to short stakes set in the ground; or, if such are conveniently situated, on the heavier foundations used to support pipe connections. In either case the wire may be covered with trunking, which see. The wire by which a signal is pulled to the clear position is called the front wire; that used to pull it to the stop position is the back wire. This last is sometimes omitted. In Europe it is generally omitted, as the counterweight, close to the signal arm, is depended on to pull the arm to the stop position when the front wire is slackened. In case of breakage of the front wire, the counterweight is designed to pull the arm to the stop position. Where a signal wire line must be sharply turned to one side, a piece is cut out and a chain inserted in place of the wire, and the chain runs around a grooved wheel. In consequence of the difficulty of adjusting signal wires, when they are lengthened or shortened by changes in temperature, rods (pipe) are now generally used, except for signals, very far from the cabin. For these signals at a distance the wire must be adjusted when necessary by screws in the cabin; or an automatic wire compensator is used. To avoid the difficulties connected with long-distance signal connections many companies use, to operate distant signals, electric motors (fixed at the signal), such as are used for automatic block signals. These are controlled by an electrical connection from the cabin.

Wire Compensator. In a mechanical interlocking plant, a device for automatically keeping the length of a wire uniform under variations in temperature. See **Compensator.** See Figs. 1333-1338, 1477-1478.

Wire Run. In an interlocking plant, an assemblage of wire lines, with their carriers and foundations, in a common course.

"Wireless" Automatic Block System. A term used to define that arrangement of automatic block signals in which line wires for the control of distant signals are dispensed with. The home signal controls the clearing of the distant signal by changing the polarity of the track circuit which extends from the home back to its distant. When the polarity is changed there is a brief period of time during which no current flows. To prevent this from opening the signal circuit and wrongfully putting the home signal in the stop position a "slow-acting" relay or slow releasing slot is used; before the armature falls the current is restored. See Figs. 345-348, 377-380, 420.

Wood Filler. See **Insulated Rail Joint.**

Z

Z Armature. An armature (of an electro-magnet) shaped like the letter Z; used in enclosed disk signals, switch indicators, etc. See Figs. 401-407.

Zorge Torpedo Placer. See **Torpedo Placer.**

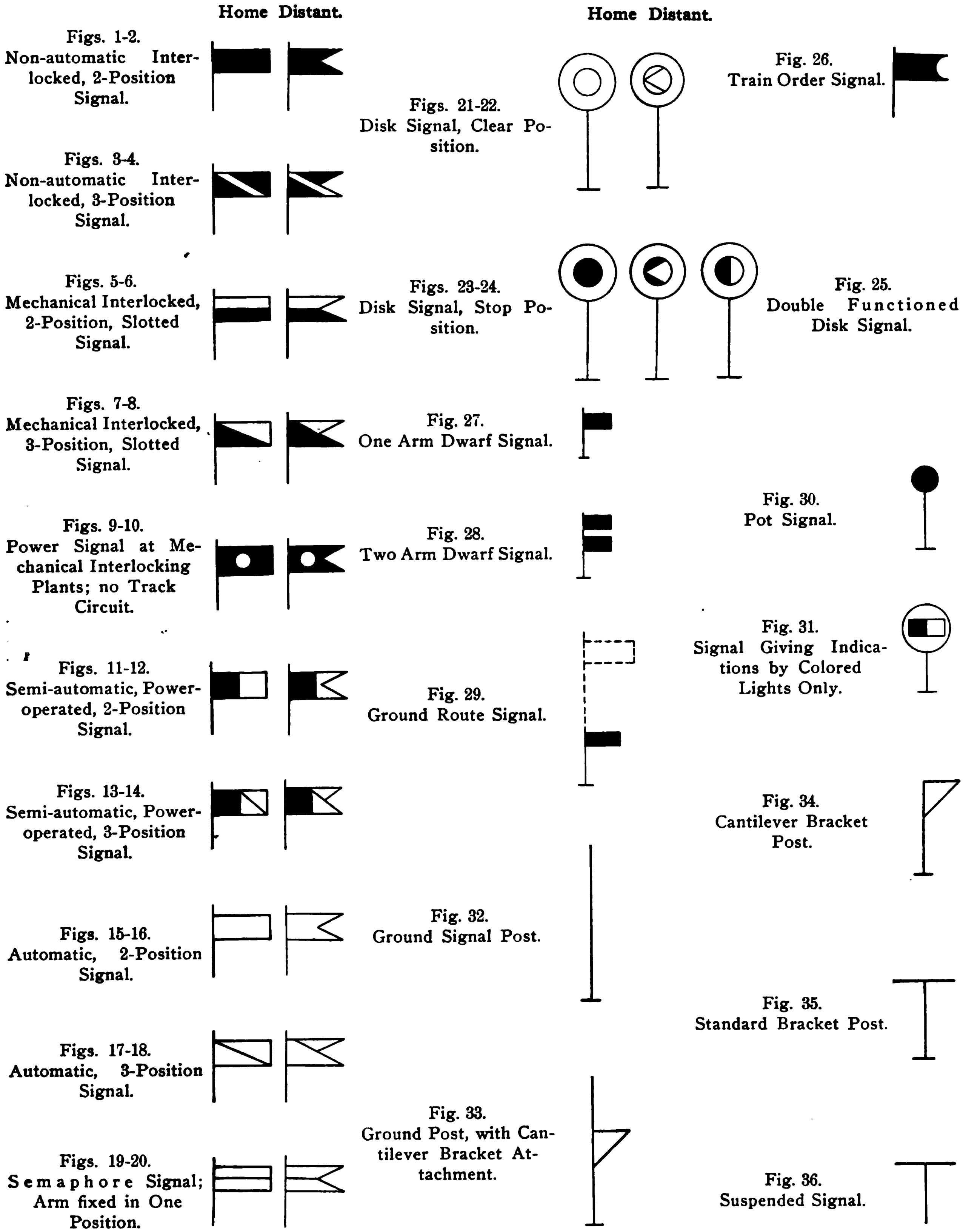
CLASSIFIED INDEX TO ENGRAVINGS

The engravings on the following pages, 3,120 in all, are arranged under the five general heads given below. The page number is put at the bottom of the page on the inside corner, and the inclusive figure numbers at the top of the page on the outside corner. The symbols commonly used in making signal drawings will be found on pages 1 to 5 inclusive, Figs. 1-124.

If the above general arrangement be borne in mind, there will be no difficulty in turning at once to any class of engravings desired. The following detailed index of titles and sub-titles is arranged according to the consecutive order of each subdivision. The page and figure numbers given are those under which the first engraving in any group of a given class of engravings appears.

ALPHABETICAL INDEX TO ENGRAVINGS

These symbols for the apparatus commonly shown on signal drawings have been adopted as standard by the principal companies making signal apparatus, and by most of the railroads. They have been used in making the illustrations for this book.



Figs. 1-36. Standard Symbols for Signals and Signal Posts.

Numbers Refer to List of Names Below.

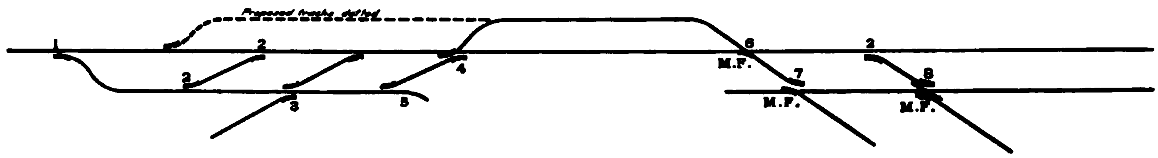


Fig. 37. Symbols for Interlocked Switches where Track is Shown by Single Line.

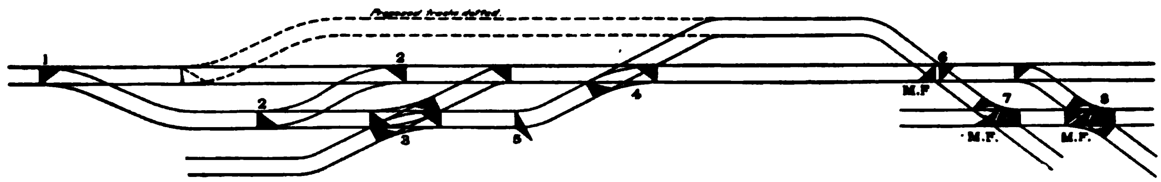


Fig. 38. Symbols for Interlocked Switches where Track is Shown by a Line for Each Rail.
The solid black triangles, as at 1, show the normal position of the switch. Switch 1 lies normally for the straight track.

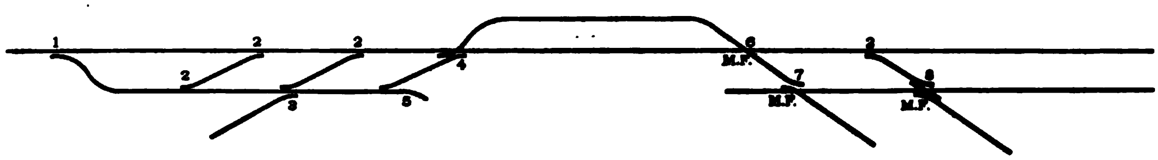


Fig. 39. Symbols for Non-Interlocked Switches where Track is Shown by Single Line.

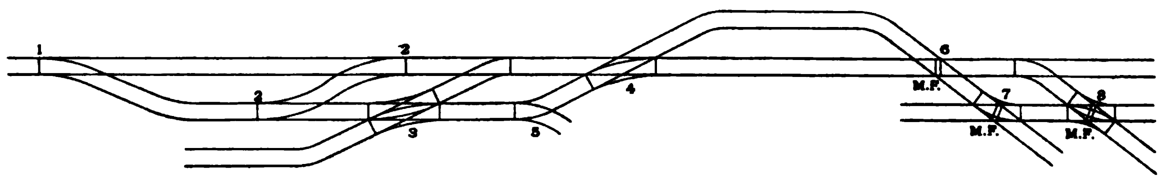


Fig. 40. Symbols for Non-Interlocked Switches where Track is Shown by a Line for Each Rail.

Names of Parts of Figs. 37-40.

1 *Simple Turnout*
2 *Simple Crossover*
3 *Double Slip Switch*
4 *Single Slip Switch*
5 *Derailing Switch*
6 *Movable Frog in Crossing*
7 *Single Slip Switch with Movable Frogs*
8 *Double Slip Switch with Movable Frogs*

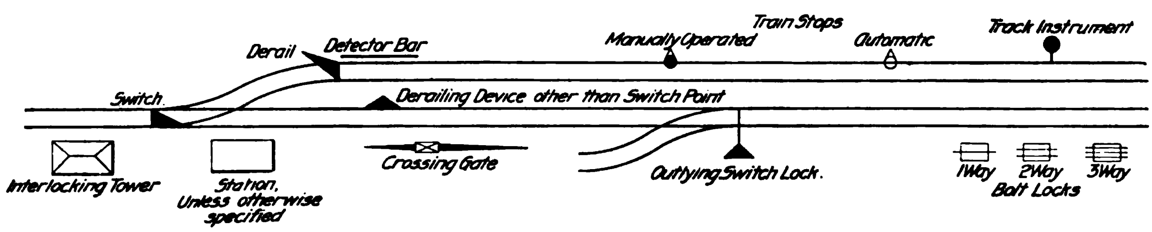


Fig. 41. Location Symbols at Interlocking Plants.

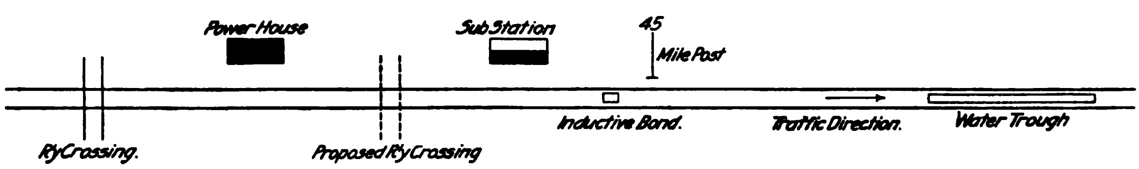


Fig. 42. Location Symbols for Structures on or Adjacent to Tracks.

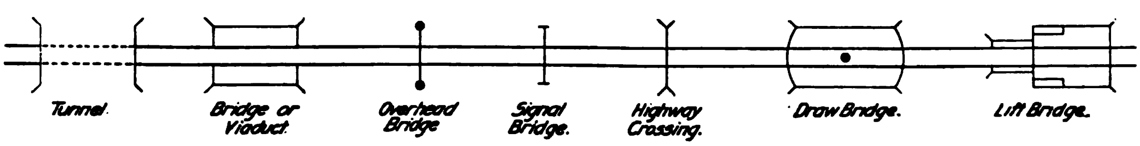


Fig. 43. Location Symbols for Structures on or Over Tracks.


Fig. 44. Switch Indicator, Semaphore Type.

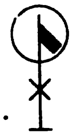


Fig. 45. Switch Indicator, Semaphore Type, and Switch Box.

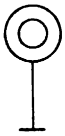


Fig. 46. Switch Indicator, Disk Type.

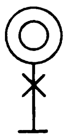


Fig. 47. Switch Indicator, Disk Type, and Switch Box.


Fig. 48. Switch Box Location.

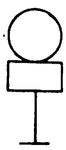


Fig. 49. Switch Bell.

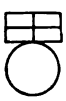


Fig. 50. Highway Crossing Bell.

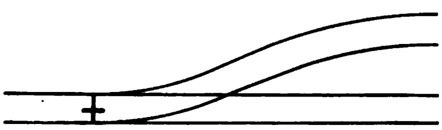


Fig. 51. Insulated Switch Rod.


Fig. 52. Battery Chute.

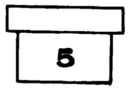


Fig. 53. Battery Cupboard.


Fig. 54. Battery Shelter, Above Ground.


Fig. 55. Battery Shelter, Half Above Ground.


Fig. 56. Battery Shelter. Below Ground.


Fig. 57. Relay Box.

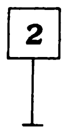


Fig. 58. Relay Box and Post.

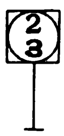


Fig. 59. Battery Chute, Relay Box and Post. Upper Figure Refers to Relay Box.

NOTE.—Figures Indicate Capacity of Box or Chute.

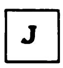


Fig. 60. Junction Box.


Fig. 61. Terminal Box.

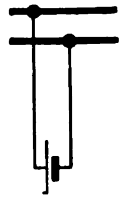
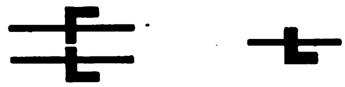


Fig. 62. Track Battery.


Figs. 63-64. Insulated Joints; Track Circuits in Both Directions.


Figs. 65-66. Insulated Joints; Track Circuit on Left, no Track Circuit on Right.


Figs. 67-68. Insulated Joints; Track Circuit on Right, no Track Circuit on Left.

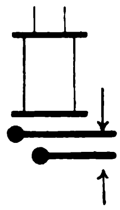


Fig. 69. Direct Current Neutral Relay; Separate Front and Back Contacts.

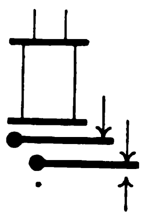


Fig. 70. Direct Current Neutral Relay; Two Front and One Back Contact.

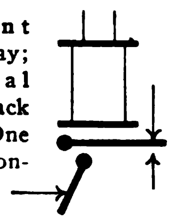


Fig. 71. Direct Current Polarized Relay; One Neutral Front and Back Contact and One Polarized Contact.

Fig. 72.
Direct Current Polarized Relay; Two Neutral and Two Polarized Contacts.

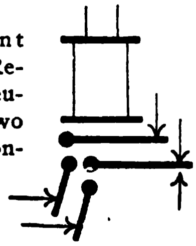


Fig. 79.
Indicator, Semaphore Type, with Bell.

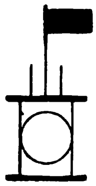


Fig. 85.
Alternating Current Relay.

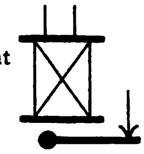


Fig. 73.
Direct Current Pole-Changing Relay.

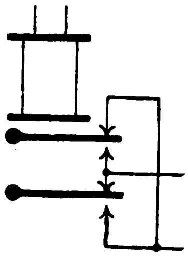


Fig. 80.
Indicator, Revolving Disk Type; Indicates Stop when Energized.

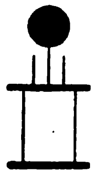


Fig. 86.
Alternating Current Relay, with Rotating Armature.

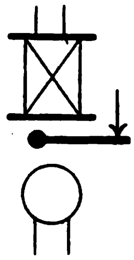


Fig. 74.
Direct Current Relay, with Differential Winding.

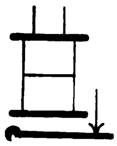


Fig. 81.
Indicator, Revolving Disk Type; Indicates Clear when Energized.

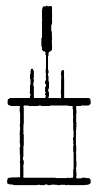


Fig. 87.
Relay, with Heavy Current Contact.

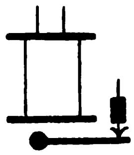


Fig. 76.
Indicator, Semaphore Type; Indicates Stop when Energized.

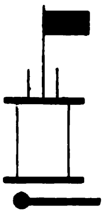


Fig. 82.
Indicator, Revolving Disk Type, with Bell.

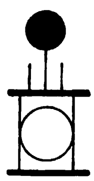


Fig. 88.
Spring Hand Key; Normally Closed.

Fig. 89.
Spring Hand Key; Normally Open.

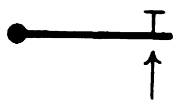


Fig. 77.
Indicator Semaphore Type; Indicates Clear when Energized.

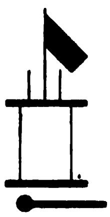


Fig. 83.
Indicator, Disappearing Disk Type, with Bell.

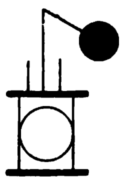


Fig. 90.
Spring Hand Key; One Contact Normally Closed and One Normally Open.

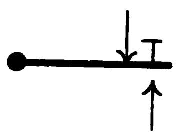


Fig. 78.
Indicator, Semaphore Type, with Contact.

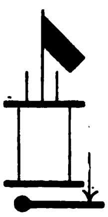
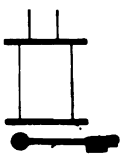


Fig. 84.
Electric Lock.



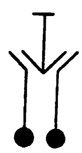


Fig. 91.
Floor Push.

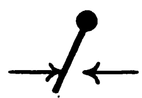


Fig. 92.
Circuit Switch.

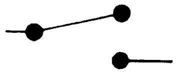


Fig. 93.
Circuit Controller on Lever of Mechanical Interlocking Machine; Normally Open.


Fig. 94.
Circuit Controller; Normally Closed.

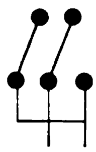


Fig. 95.
Pole Changing Switch.

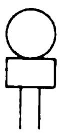


Fig. 96.
Bell.

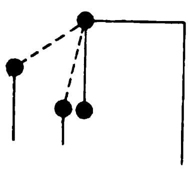


Fig. 97.
Circuit Controller on Signal.

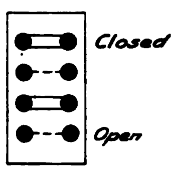


Fig. 98.
Switch Box.

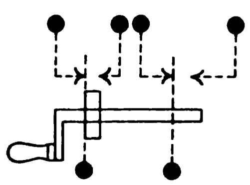


Fig. 99.
Electric Screw-Release.


Fig. 100.
Track Instrument Contact.

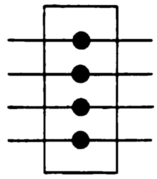


Fig. 101.
Junction or Terminal Box.

Fig. 102.
Motor.

Fig. 103.
Generator.

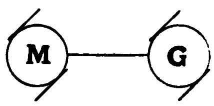


Fig. 104.
Motor-Generator.

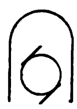


Fig. 105.
Magneto-Generator.

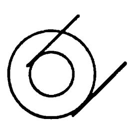


Fig. 106.
Alternator.


Fig. 107.
Fuse.

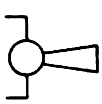


Fig. 108.
Automatic Cut-out.

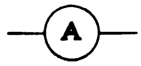


Fig. 109.
Ammeter.

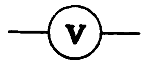


Fig. 110.
Voltmeter.

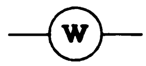


Fig. 111.
Wattmeter.

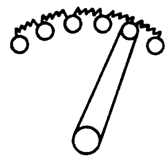


Fig. 112.
Rheostat.

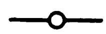


Fig. 113.
Incandescent Lamp.

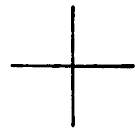


Fig. 114.
Wires Cross (no connection).

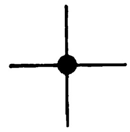


Fig. 115.
Wires Join.


Fig. 116.
Lightning Arrester.

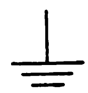


Fig. 117.
Ground.

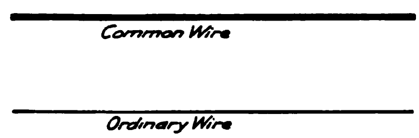


Fig. 118. Wires.

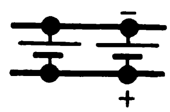


Fig. 119. Cells in Multiple.

Fig. 120. Cells in Series.

Figs. 119-120. Battery.

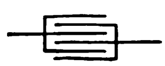


Fig. 121.
Condenser.

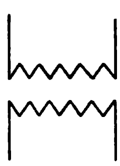


Fig. 122.
Transformer.


Fig. 123.
Fixed Resistance.

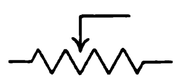


Fig. 124.
Variable Resistance.

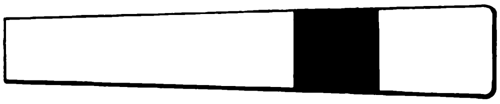


Fig. 125. Square End Semaphore Blade.

Used for Block and Interlocking Home Signals.

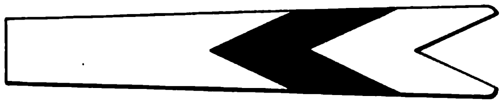


Fig. 126. Notched or Fish Tail Semaphore Blade.

Used for Block and Interlocking Distant Signals.

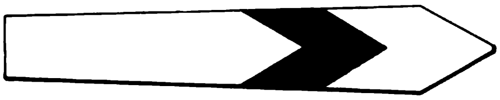


Fig. 127. Pointed End Semaphore Blade.

Usually Used for Automatic Home Block Signals, or for Train Order Signals.

Fig. 128. Round End Semaphore.

Used for Train Order Signal, for Block Signal, or for Interlocking Signals under special rules.

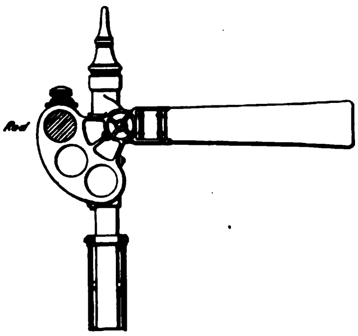


Fig. 129.

Fig. 130.

Figs. 129-130. Semaphore Home Block Signals, Two Position.

Fig 129 shows arm in stop position indicating block is occupied. Fig. 130 shows proceed position indicating block is clear.

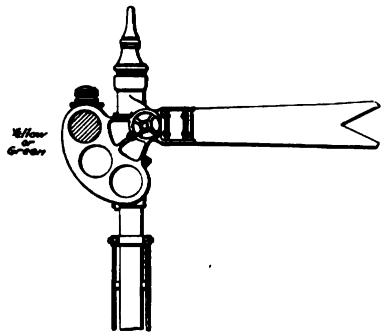


Fig. 131.

Fig. 132.

Figs. 131-132. Semaphore Distant Block Signals, Two Position.

Fig. 131 shows arm in caution position indicating prepare to stop at next home signal. Fig. 132 shows clear position indicating next home signal is in proceed position and block in advance is clear.

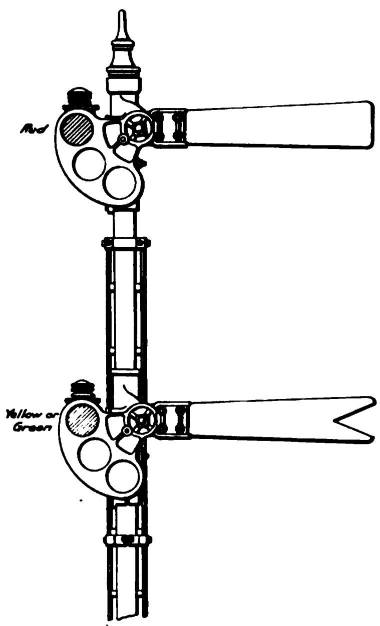


Fig. 133.

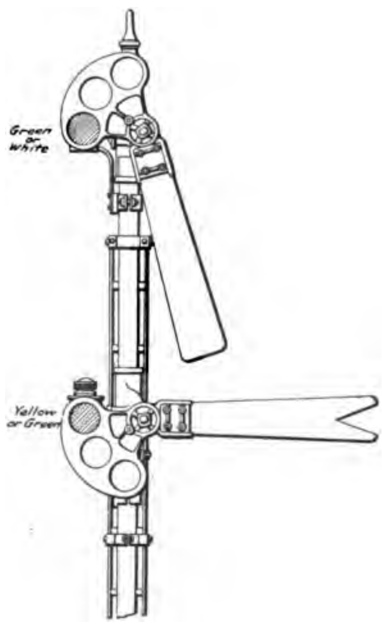


Fig. 134.

Fig. 135.

Figs. 133-135. Semaphore Home and Distant Block Signals on Same Post.

Fig. 133 shows home arm horizontal indicating stop, block is occupied; distant arm horizontal indicating be prepared to stop at next home signal. Fig. 134 shows home arm cleared and distant arm at caution, indicating proceed, block is clear but next home signal in advance is in stop position. Fig. 135 shows both home and distant arms in clear position indicating proceed, block is clear and next home signal in advance is also in clear position.

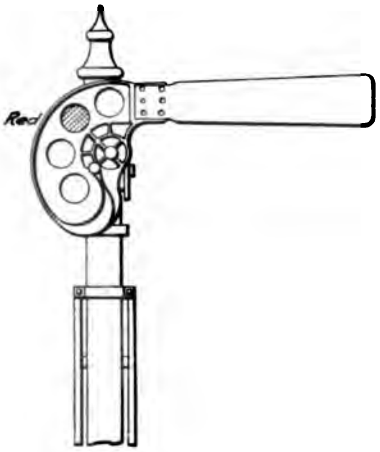


Fig. 136.

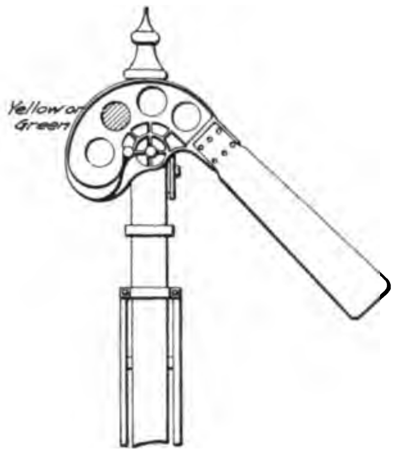


Fig. 137.

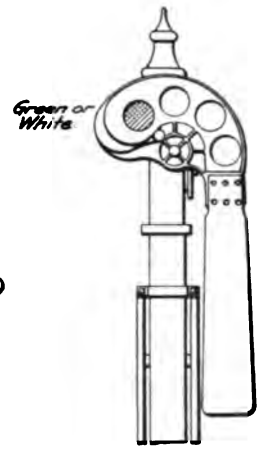


Fig. 138.

Figs. 136-138. Three-Position Semaphore Block Signal, Downward Inclination.

Fig. 136 shows arm in stop position indicating block is occupied. Fig. 137 shows arm in caution position indicating proceed, block is clear but next signal in advance is in stop position. Fig. 138 shows arm in clear position indicating proceed; block is clear and next signal in advance is in either clear or caution position.

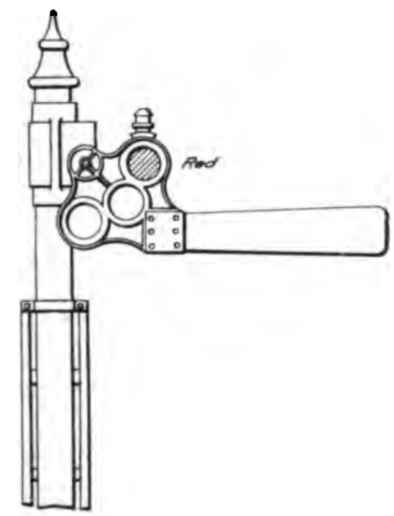


Fig. 139. Stop.

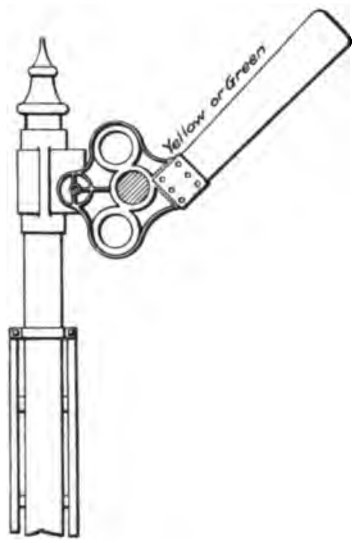


Fig. 140. Caution.

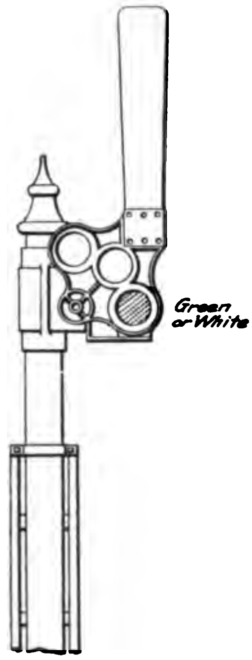


Fig. 141. Clear.

Figs. 139-141. Three-Position Semaphore Block Signal, Upward Inclination.

The indications are the same as the corresponding downward inclinations shown in Figs. 136-138.

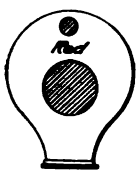


Fig. 143. Stop.

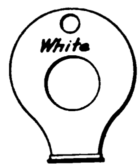


Fig. 144. Proceed.

Figs. 143-144. Disk Home Block Signal.

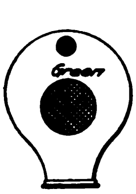


Fig. 145. Caution.

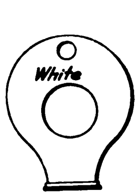


Fig. 146. Clear.

Figs. 145-146. Disk Distant Block Signal.

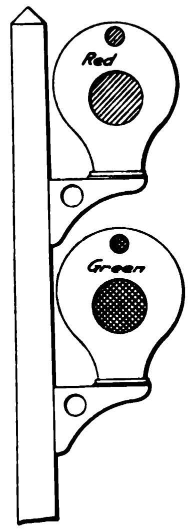


Fig. 147. Disk Home and Distant Signal on Same Post. The Red Indicates Stop, the Green Indicates Be Prepared to Stop at Next Signal in Advance.

Fig. 147.

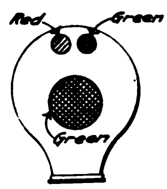


Fig. 148. Caution.

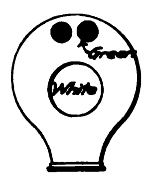
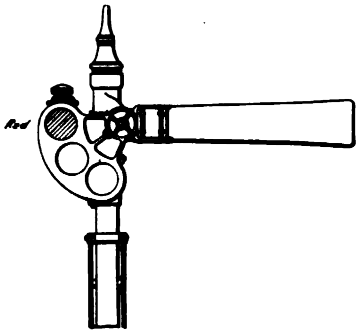
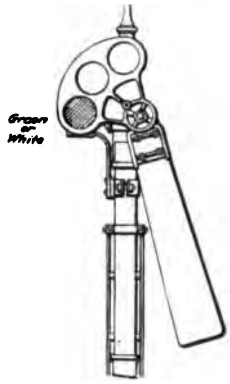


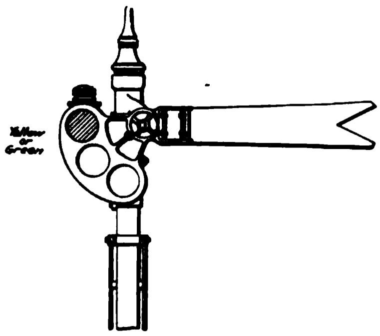
Fig. 149. Clear.

Figs. 148-149. Chicago & North-Western Two-Light Disk Distant Block Signal.

The red light is obscured when the signal indicates clear.







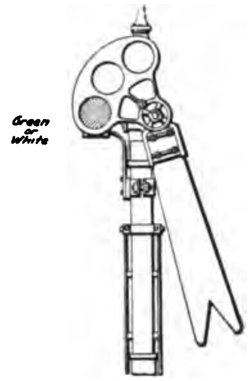


Fig. 150. Stop. Fig. 151. Proceed.

Figs. 150-151. One-Arm Semaphore Interlocking Home Signal.

Fig. 152. Caution.

Fig. 153. Clear, Indicating That Next Home Signal is at "Proceed."

Figs. 152-153. One-Arm Semaphore Interlocking Distant Signal.

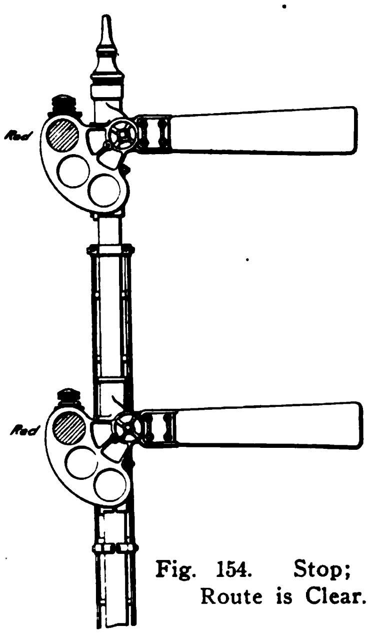


Fig. 154. Stop; no Route is Clear.

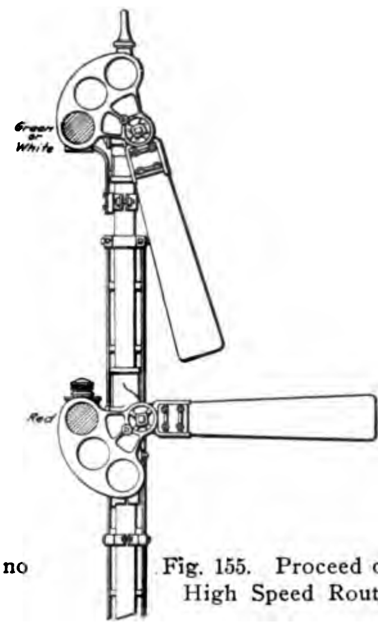


Fig. 155. Proceed over High Speed Route.

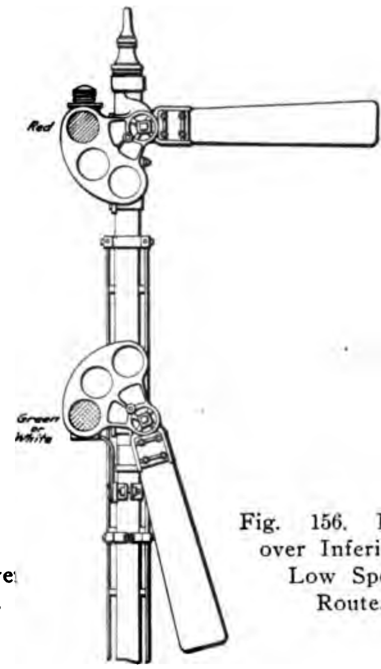


Fig. 156. Proceed over Inferior or Low Speed Route.

Figs. 154-156. Two-Arm Semaphore Interlocking Home Signals.

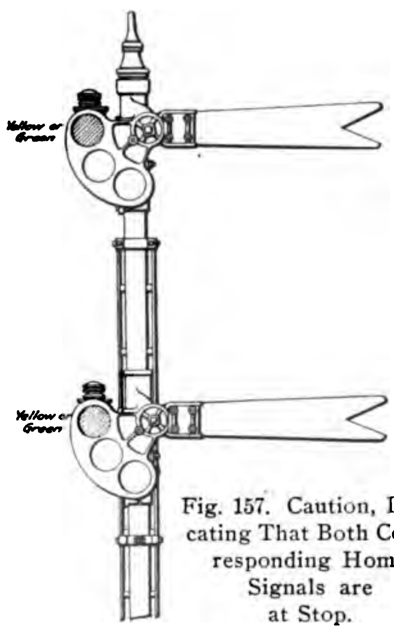


Fig. 157. Caution, Indicating That Both Corresponding Home Signals are at Stop.

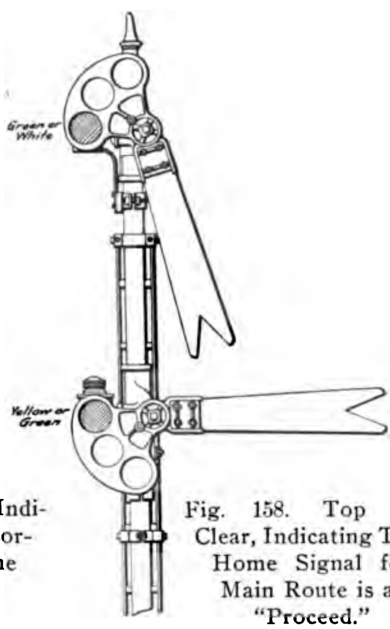


Fig. 158. Top Arm Clear, Indicating That Home Signal for Main Route is at "Proceed."

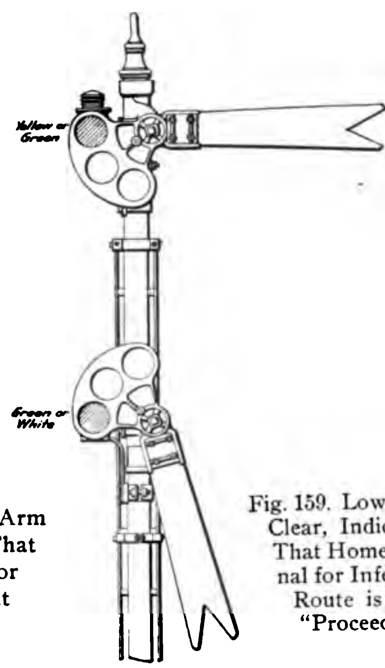


Fig. 159. Lower Arm Clear, Indicating That Home Signal for Inferior Route is at "Proceed."

Figs. 157-159. Two-Arm Semaphore Interlocking Distant Signals.

Figs. 160-163. Three-Arm Semaphore Interlocking Home Signals.

Fig. 160 indicates stop, no route is clear. Fig. 161 indicates proceed over main or high speed route. Fig. 162 indicates proceed over medium speed route. Fig. 163 indicates proceed over low speed inferior route. This arm may control movements over more than one such route.

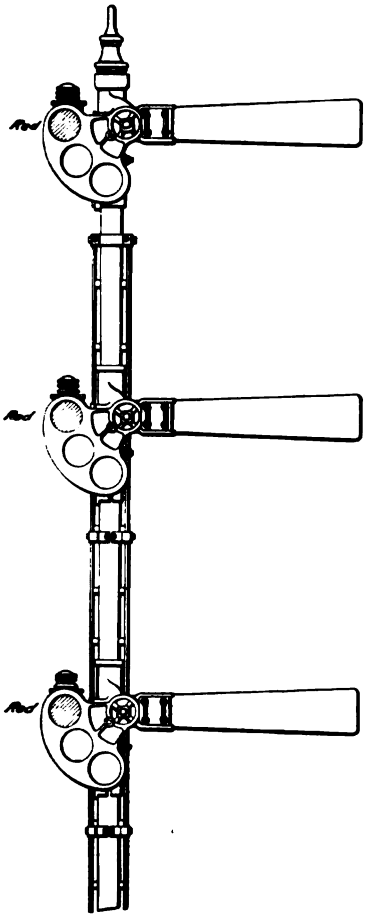


Fig. 160.

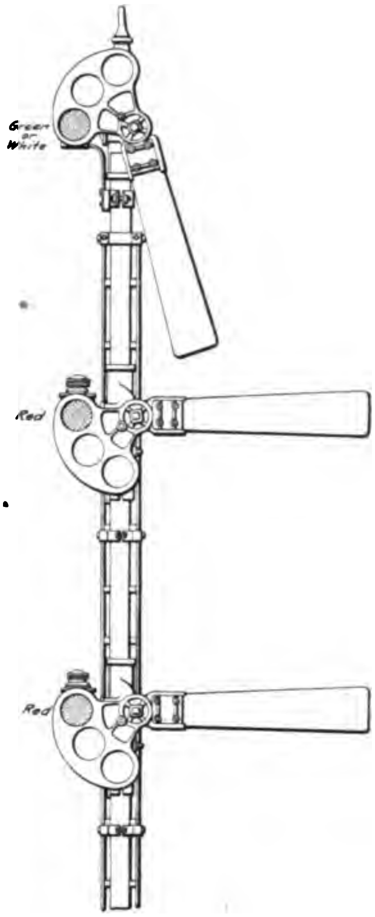


Fig. 161.

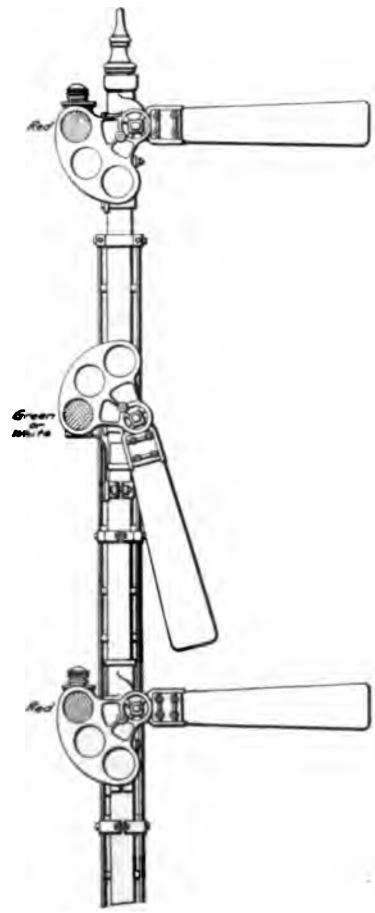


Fig. 162.

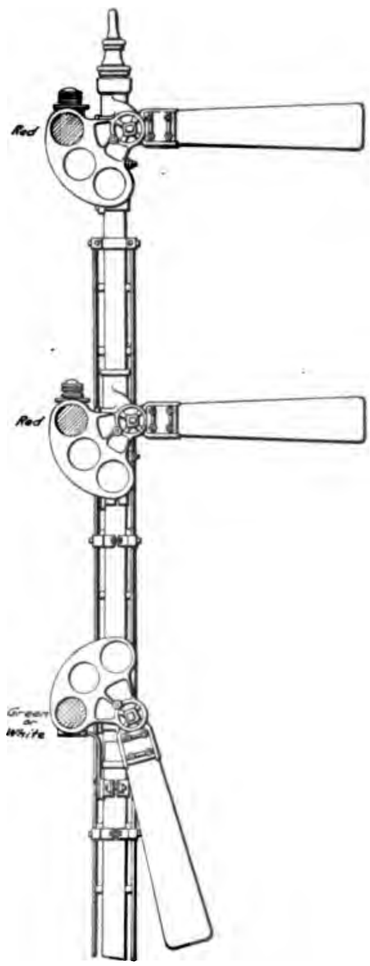


Fig. 163.

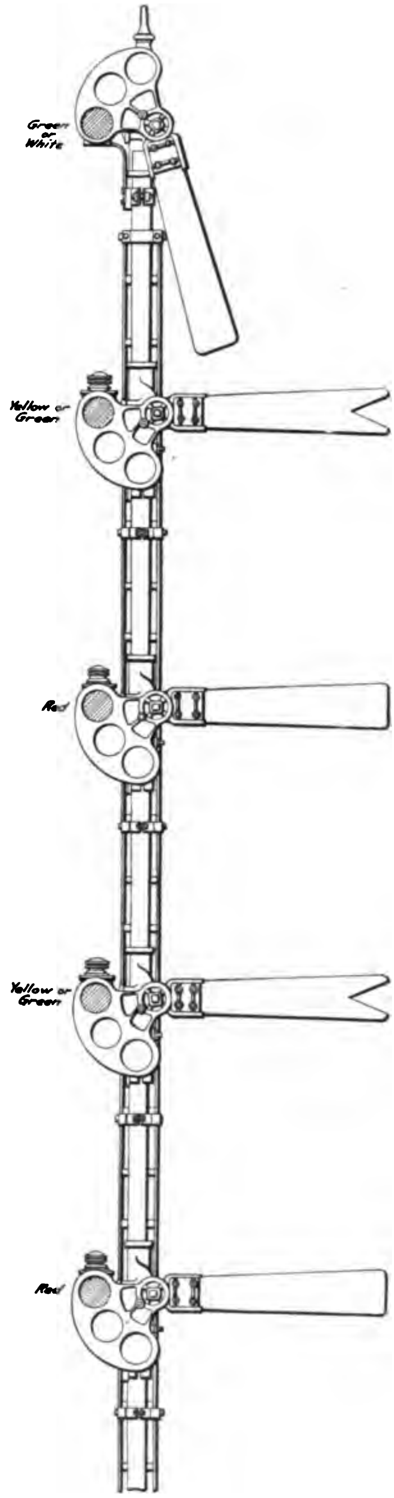
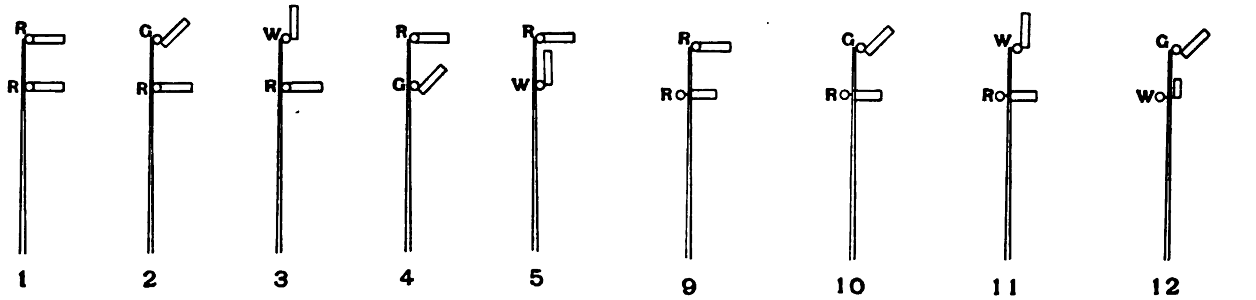
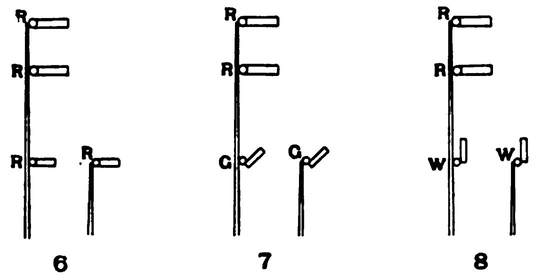


Fig. 164. Five-Arm Semaphore Interlocking Signal, with Home and Distant Arms; Indicating Proceed over High Speed Route.

The three home signal arms correspond with the three home signal arms shown in Figs. 160-163. Each distant signal arm gives indication for the next home signal on the same route as that for which the home arm immediately above it indicates. See Fig. 205.





Numbers 1 to 8, inclusive, are Class "A," "Stop and Stay." The first five show indications for high and moderate speeds, and the other three show indications for low speeds, as follows: 1—Stop and stay; 2—Proceed with caution to next signal, on high-speed track; 3—Proceed at high speed, on high-speed track; 4—Proceed with caution to next signal, on moderate-speed track; 5—Proceed at moderate speed, on moderate-speed track; 6—Stop and stay; 7—Proceed with caution, on low-speed track; 8—Proceed at low speed, on low-speed track. The lights are in a vertical line.

Numbers 9 to 12, inclusive, are Class "B," "Stop, Wait Time and Proceed" signals. These are for the automatic system and also for distant signals when the latter are used to give an independent indication; 9—Indicates stop, and proceed after waiting time; 10—Proceed to next signal, prepared to stop; 11—Proceed at full speed, next high speed signal at caution or clear; 12—Proceed at moderate speed; next moderate-speed signal at caution or clear. The lower light is staggered to the left.

In all the figures R indicates a red light; G, green; W, white.

Figs. 165-176. Three-Position Upward Inclination Block and Interlocking Signals, with Two High Arms, as installed on the Central Division of the Philadelphia, Baltimore & Washington Railroad.

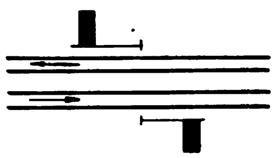


Fig. 177. Separate Ground Post Signals for Each Track.

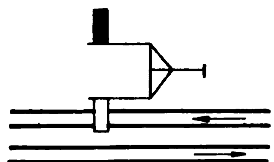


Fig. 178. Signals for Both Tracks Mounted on Bracket Post at One Side.

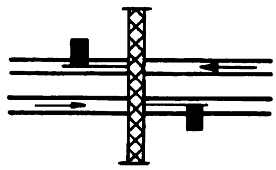


Fig. 179. Signals for Both Tracks Mounted on Bridge over Tracks.

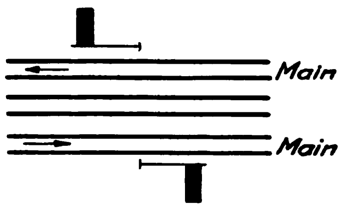


Fig. 180. Separate Ground Post Signals for Outside Tracks; Middle Track Not Signaled.

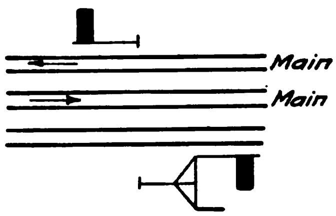


Fig. 181. Ground Post Signal and Bracket Post Signal for Outside and Middle Track. Dummy on Bracket Post to Indicate that the Other Outside Track is Not Signaled.

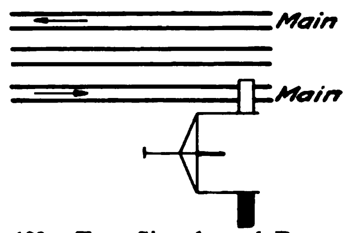


Fig. 182. Two Signals and Dummy in Center on one Bracket Post; Middle Track Not Signaled.

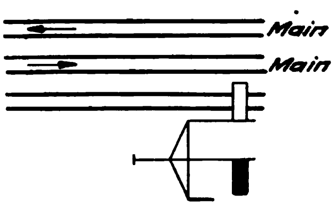


Fig. 183. Two Signals and Dummy on One Bracket Post; One Outside Track Not Signaled.

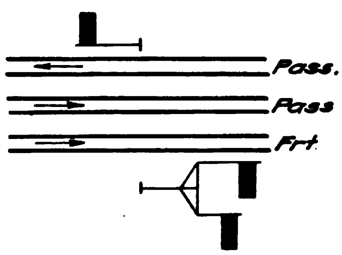


Fig. 184. Ground Post Signal for High Speed Track on Outside; Bracket Post, with High Arm for Middle Track and Lower Arm for Freight or Low Speed Track on Outside.

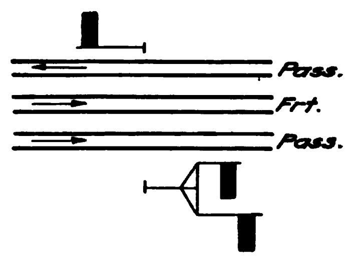


Fig. 185. Same as Fig. 184, Except Low Speed Track is Between High Speed Tracks.

Figs. 177-185. Locations of Signals with Reference to Tracks over which They Govern Train Movements.

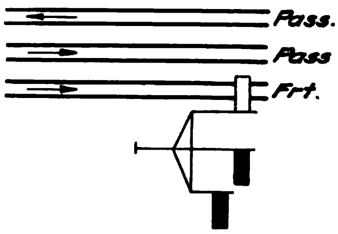


Fig. 186. Three Signal Arms on One Bracket Post; Low Speed Track on Outside and Low Signal Arm also on Outside.

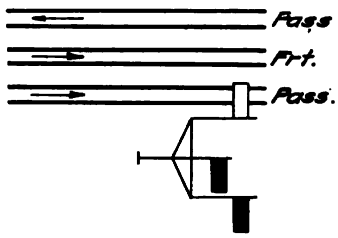


Fig. 187. Three Signal Arms on One Bracket Post; Low Arm for Low Speed Track in Center.

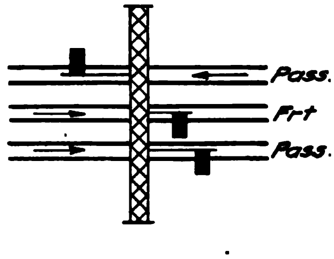


Fig. 188. Signals for Each Track on Bridge over Track for which they Indicate; Low Speed Track in Center.

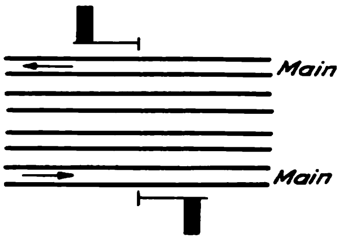


Fig. 189. Only the Two Outside Tracks are Signaled.

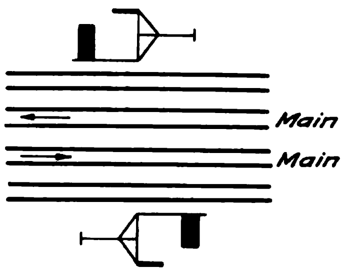


Fig. 190. Bracket Post Signals, with Dummies; Two Middle Tracks Only, Signaled.

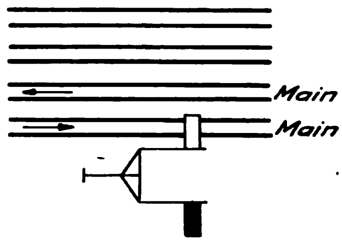


Fig. 191. Bracket Post Signals for Two Lower Tracks; Other Two Tracks not Signaled.

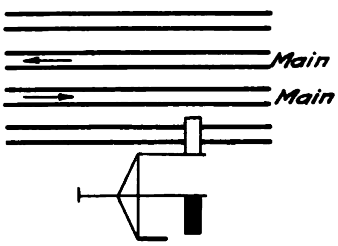


Fig. 192. Same as Fig. 190, with Both Signals on One Bracket Post, and Dummy for Outside Track, which is not Signaled.

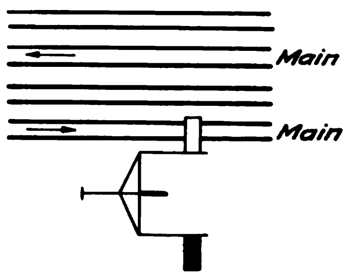


Fig. 193. Alternate Tracks Signaled. Two Arms and Dummy on One Bracket Post.

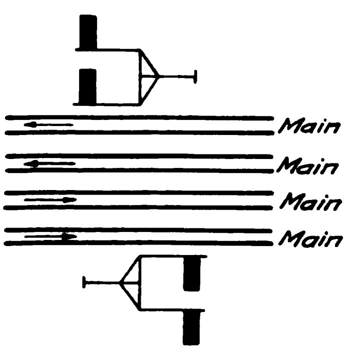


Fig. 194. Four Tracks Signaled; Two High Arms on Each Bracket Post.

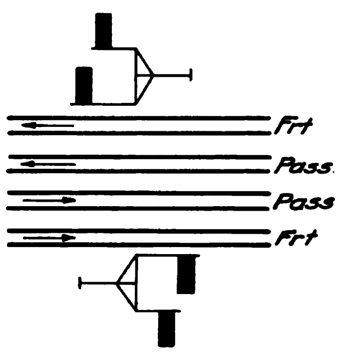


Fig. 195. Same as Fig. 194, Except Outside Tracks Are for Low Speed Movements, with Low Arms Indicating for Same.

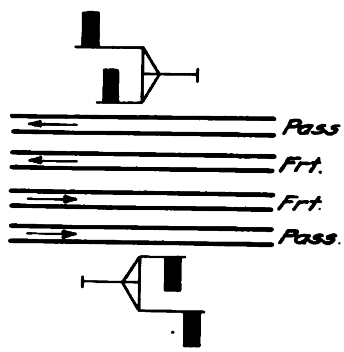


Fig. 196. Same as Fig. 195, Except Middle Tracks Are for Low Speed Movements and Low Arms are on Inside Dolls of Bracket Post.

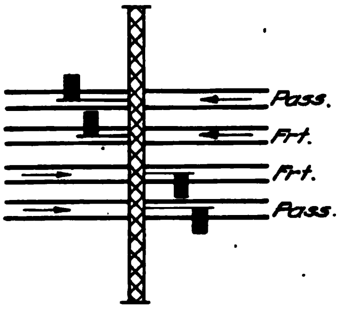


Fig. 197. Four Tracks Signaled. All Signals Mounted on Bridge; Low Signals for Low Speed Tracks.

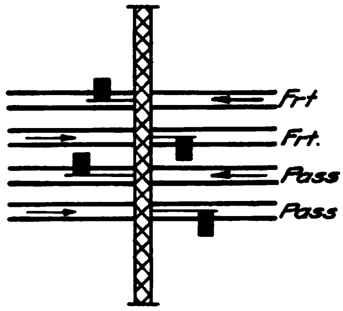


Fig. 198. Same as Fig. 197, but with Different Arrangement of Tracks.

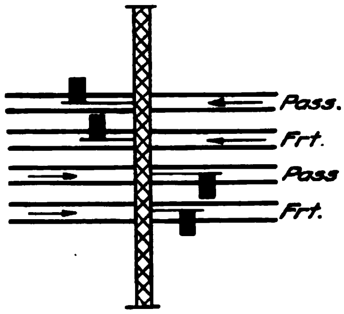


Fig. 199. Same as Fig. 197, but with Different Arrangement of Tracks.

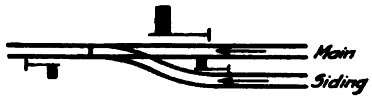


Fig. 200. Trailing Point Siding Switch.

The high signal when cleared indicates that the switch is set for movements over the main track in the direction of the arrow; when in the stop position it indicates that the switch may be set for movements to or from the siding. The dwarf signals govern movements into or out of the siding and also reverse movements on the main track. The dwarf signals are sometimes omitted at isolated switches which are not much used.

Fig. 201. Signals Governing Over Diverging Routes

The upper arm governs movements over the main route. The middle arm governs movements over the next inferior route. The lower arm governs movements over the least important route, and may be made to indicate for any number of low-speed routes inferior to that governed by the middle arm.

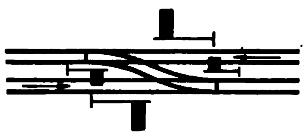


Fig. 202. Trailing Point Crossover.

The function of the high and dwarf arms is the same as in Fig. 200. The signal arms and the two switches are worked in conjunction with each other, both high arms being free to be cleared when the switches are set for main track movements and both dwarf signals being free to be cleared for reverse movements when the switches are set for the straight track or for the crossover.

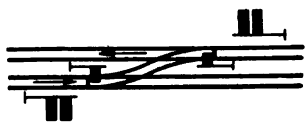


Fig. 203. Facing Point Crossover.

The lower arms of the high signals govern movements through the crossover. The dwarf signals govern reverse movements on the straight track over the crossover switches.

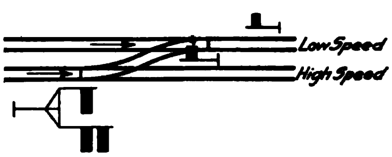


Fig. 204. Crossover from High Speed Track to Low Speed Track.

The single arm is for the low-speed track, there being but one possible movement on that track in the normal direction. The double arm high signal for the high speed track corresponds to Fig. 203. The dwarf signals have functions similar to those in Figs. 202-203.

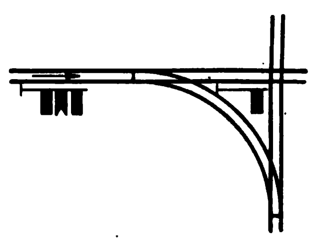
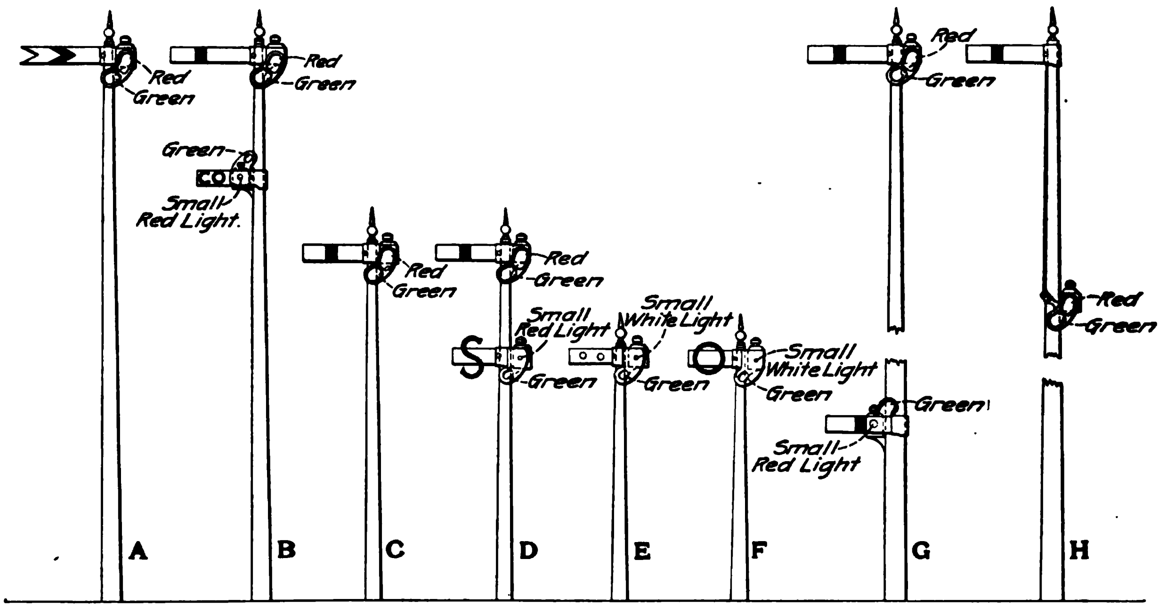


Fig. 205. Two Home and One Distant Signal on Same Post.

The upper home signal governs movements over the direct route. The distant signal is used to indicate the position of the single home signal at the crossing and the lower home signal governs movements over the diverging route.



Figs. 206-213. Standard Signals. Great Western Railway of England.

A—Distant Signal.
B—Home Signal. When required, a small calling-in arm is mounted below the high arm, as shown.
C—Starting or Advanced Starting Signal. Maximum distance from cabin 350 yards.
D—Starting Signal with Shunt Arm. Used where there are switches beyond Advance Signal.
E—Backing Signal.
F—Siding Signal.
G—Duplicate Arm Signal. Used when required on account of obstructions or poor background for top arm.
H—Extra High Signal. When the arm is more than 30 ft. high, the lamp is fixed lower down, not over 30 ft. from ground.

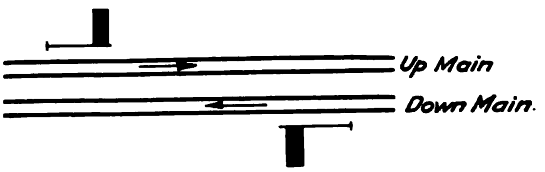


Fig. 214. Standard Location of Signals on British Railroads.

Trains run on left-hand track and signal arms point to the left.

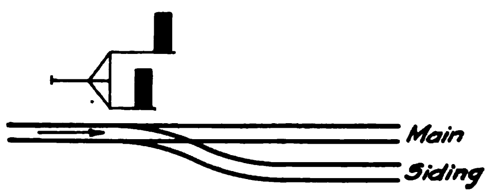


Fig. 215. Typical British Arrangement of Signals for Diverging Routes.

A bracket post is used having a doll for each arm; the arm governing movements over the main route is mounted higher than other arms. An arm governing diverging movements to the right is placed to the right of the main route arm.

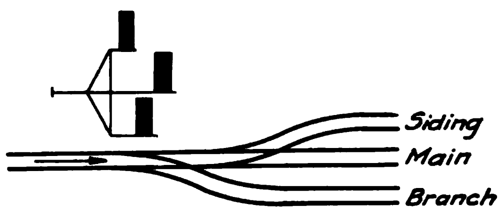


Fig. 216. Typical British Arrangement of Signals for One Main and Two Diverging Routes.

NOTE.—Typical American Practice for this situation is shown in Fig. 201.

Fig. 217. Train in Block. Protected by Signal A in Rear, Indicating Stop to Following Train.

The signal is kept in stop position until train has passed out of block beyond signal B. The length of the block is from A to B.

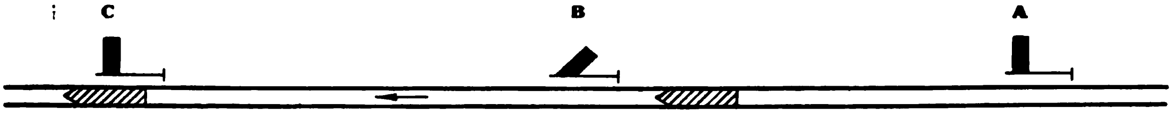


Fig. 218. Train has just passed Signal C. Signal B is clear for next train to pass B toward C.

Fig. 219. Home and Distant Block Signals.

The block section is from H1 to H2. The Distant Signals, D1 and D2, are to give to trains preliminary information as to the indication to be expected at the next home signal.

Fig. 220. Home and Distant Signals. Distant Signal Mounted on same Post with the Home Signal in the Rear.

The distance between the distant signal and the home signal by which it is governed is here made the length of the block, instead of from 1,500 ft. to 3,000 ft. as in Fig. 219.

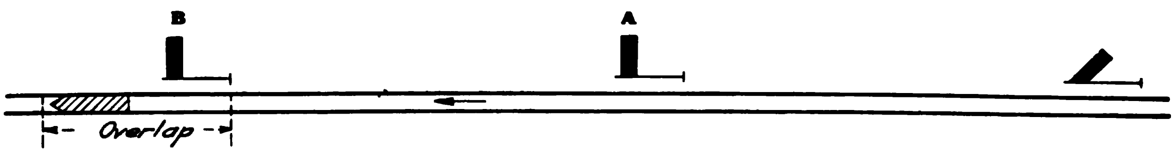


Fig. 221. Block Signals with Overlap.

Signal A indicating "stop" behind a train cannot be cleared until that train has passed beyond the overlap. See definition of "overlap."

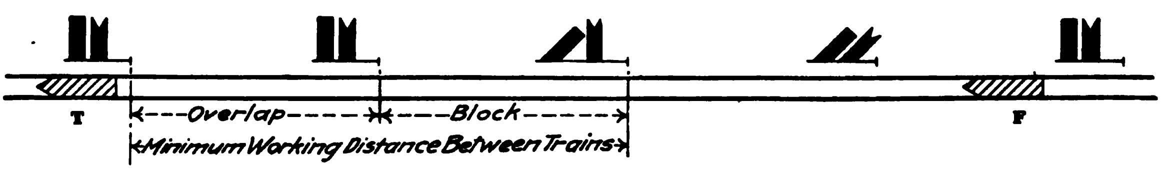


Fig. 222. Arrangement of Automatic Block Signals and Overlaps in New York City Subway.

The overlap is made the length of a block and the blocks are made as short as possible (about 25 per cent. longer than the distance required for an emergency stop for trains running at maximum speed). Automatic train stops are used at each home signal. A train is always protected by two home signals indicating stop behind it and by a distant signal indicating caution one whole block behind the second home signal in rear of the train. The distance between trains running at full speed must be more than three blocks, as shown by the situation of the trains T and F, for the distant signal must be cleared far enough in advance to be observed by train F.

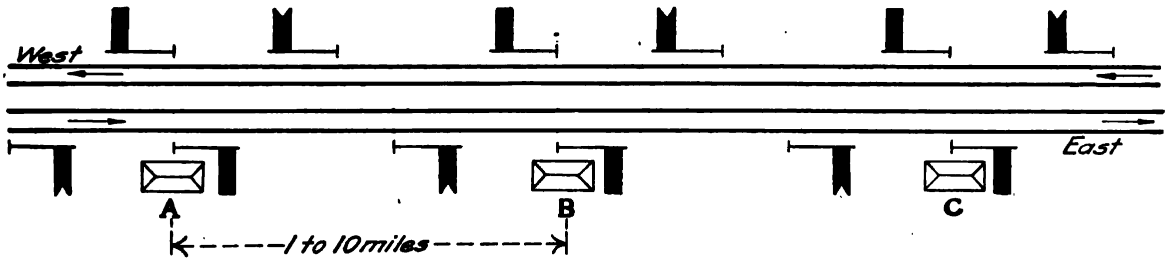


Fig. 223. Typical Arrangement of Manual Block Signals on Double Track Railroad.

The blocks are from A to B and from B to C. A signalman is stationed at each cabin and is in communication by telegraph, telephone or bell with the signalman in the next cabins east and west. An eastbound train approaching A, desires to proceed to B; the signalman at A, having received information from B that the last preceding train has arrived at B and cleared the block, clears the eastbound home signal permitting the train to enter the block. If there is (as here) a distant signal, that also is cleared. When the train has entered the block, A informs B, giving the train number and time of leaving A, and he also informs the station in the rear of A. Then B advises C, and if the block B-C is not clear, the train on arrival at B is held at the home signal at B until the block is clear when it is allowed to proceed. The same method may be applied to a single track line.

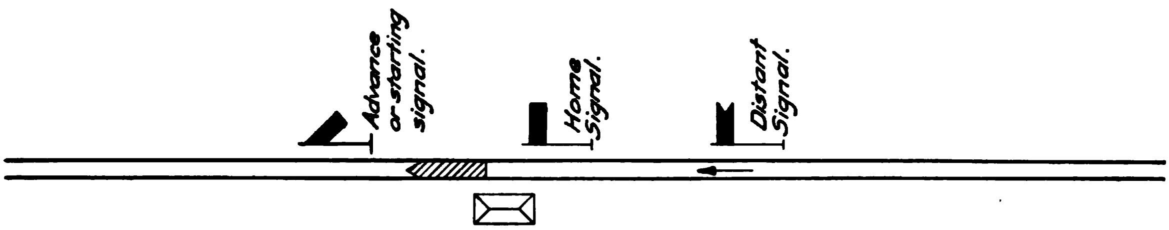


Fig. 224. Typical Arrangement of Distant, Home and Advance Signals at Manual Block Station.

Where the home signal is at or near a station platform, a train may be allowed to pass the home signal but be held at the advance signal until the block ahead is clear. In effect a short intermediate block is formed, in which a train may be held without delaying a following train entering the block at the next block station in the rear.

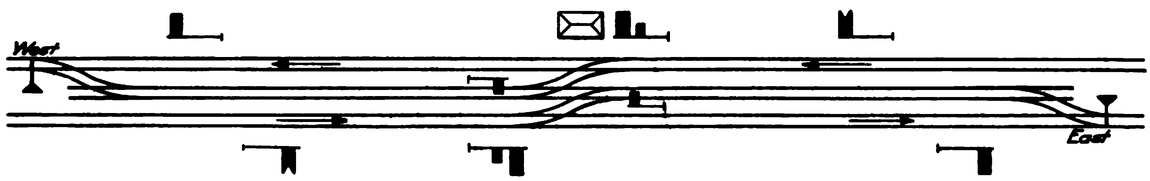


Fig. 225. Typical Arrangement of Middle Passing Track at Manual Block Stations on Erie Railroad.

The outlying switches are locked by electric locks controlled from the signal cabin. The switches near the cabin are worked by levers in the cabin which are suitably interlocked with the signal levers. The middle or passing track is about 8,000 ft. long. Home, distant and advance signals are used for each main track, and in addition dwarf and route signals at the switches opposite the cabin.

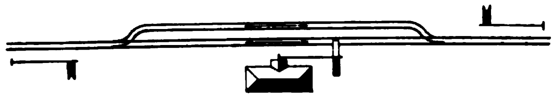


Fig. 226. Home Signals for East and West Movements on Same Post at Station.

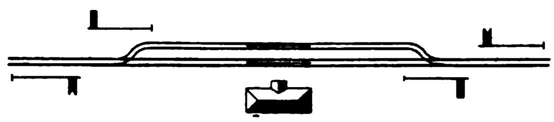


Fig. 227. Home Signals on Separate Posts Beyond Station.

Figs. 226-227. Typical Arrangements of Signals at Manual Block Stations on Single Track Roads.

The switches are not controlled from the station. Many such stations have no distant signals.

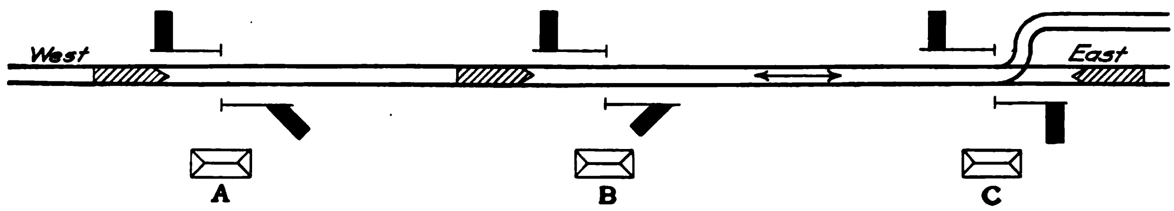


Fig. 228. Arrangement of Three-Position Arm for Permissive Blocking on Single Track Roads.

The signal at A inclined upward indicates caution for permissive blocking. The signal at B inclined downward indicates clear. The signal at C in the horizontal position indicates stop.

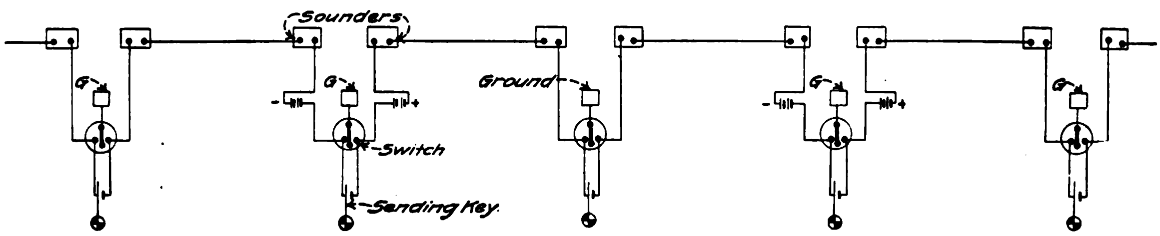


Fig. 230. Morse Telegraph Circuits Between Block Stations, with Line Battery at Alternate Stations.

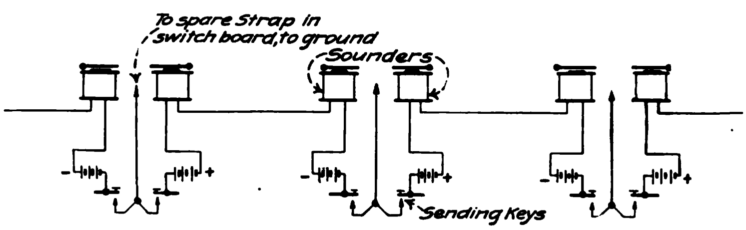


Fig. 231. Morse Telegraph Circuits Between Block Stations, with Line Battery at Each Station.

NOTE.—When line is more than 20 miles long, relays working sounders on local circuit must be used in either arrangement shown.

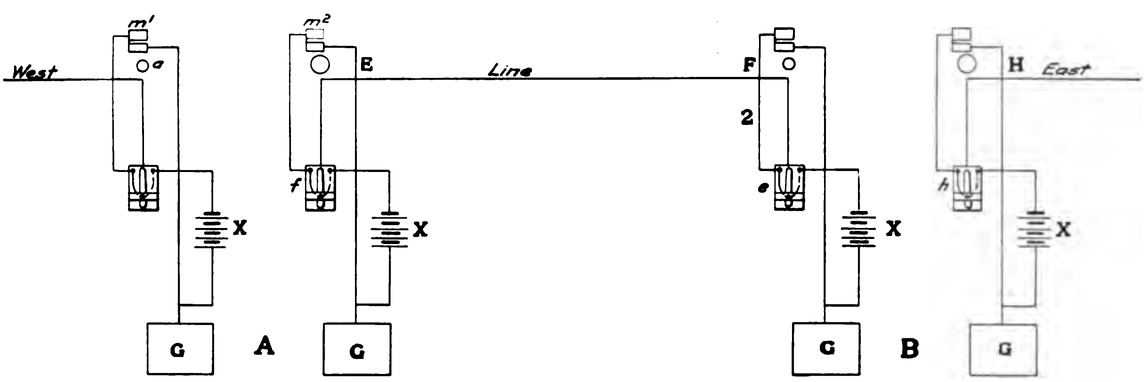
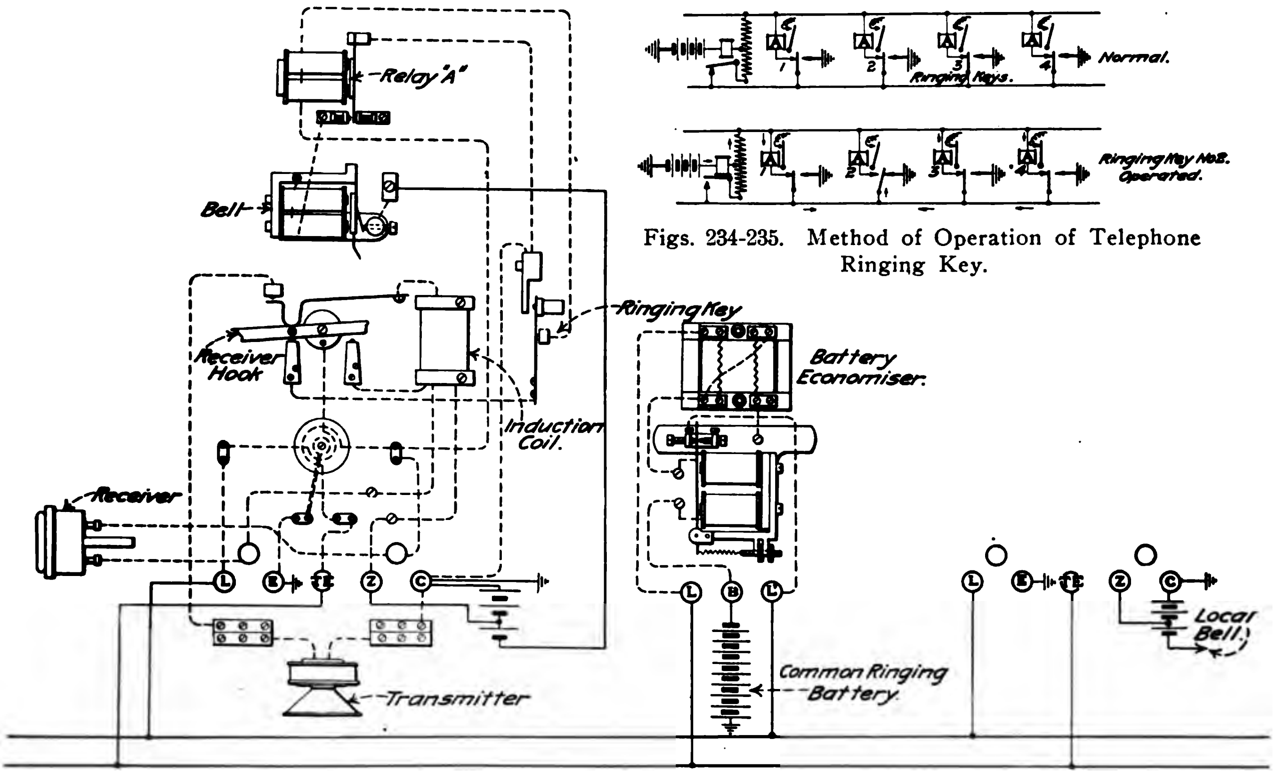


Fig. 232. Communicating Bell Circuits for Manual Block Stations; Erie Railroad.

To communicate with B the signalman at A presses key *f* which closes circuit from battery X at A through contact of key *f* (now closed), line, normally closed contact of key e at B, wire 2, bell F to ground G. When B presses key *e*, bell E at A rings through similar circuit. Each station has bell and key for eastbound and westbound communication.



Figs. 234-235. Method of Operation of Telephone Ringing Key.

Fig. 233. Telephone Communicating Circuits between Block Stations, Great Western Railway of England.

The usual telephone instruments are installed in each block station, being connected across a pair of continuous line wires as shown in Fig. 233. A common ringing battery is installed at one station which supplies current when required for energizing the relays A, used to cut in the call bells operated from local battery. In order to economize ringing battery current and to cut down noise on the line from induced current an arrangement of impedance coil and cutting-out relay is used with the ringing battery. The operation of this device is shown in Figs. 234-235. The battery is connected to ground on one side and through the relay on the other side to the center of the impedance coil. This coil is connected across the line wires, direct on one side and through a back contact of the cutting-out relay on the other side. When any ringing key is closed as at 2, Fig. 235, a path is closed to ground from the lower line wire. Current flows from ringing battery on upper line wire through all the bell relays A, except that at 2, across the line and through lower line wire toward 2, where connection is made with ground. No current flows direct from battery to ground over lower line wire because the cutting-out relay is energized by the current flowing through the upper line wire and opens the back contact to lower line wire. All of the bell relays A, except that at 2, are energized and the bells ring simultaneously, the circuit being from local battery through the bell, closed on relay A, ringing key terminal, back to battery. As soon as the ringing key at 2 is opened again the path to ground is broken, all bell relays A are de-energized, the bells cease ringing, and the cutting-out relay drops to its normal position, as shown in Fig. 234. The impedance across the line at the ringing battery permits induced currents to pass equally from each line to ground, and prevents noise on the telephone circuit. The bell relays A are of high resistance and are not affected by the current flowing on the telephone circuit.

Fig. 236. Instrument Open.

Fig. 237. Front View of Instrument Closed.

Figs. 236-237. Repeating Block Instrument, Lancashire & Yorkshire Railway.

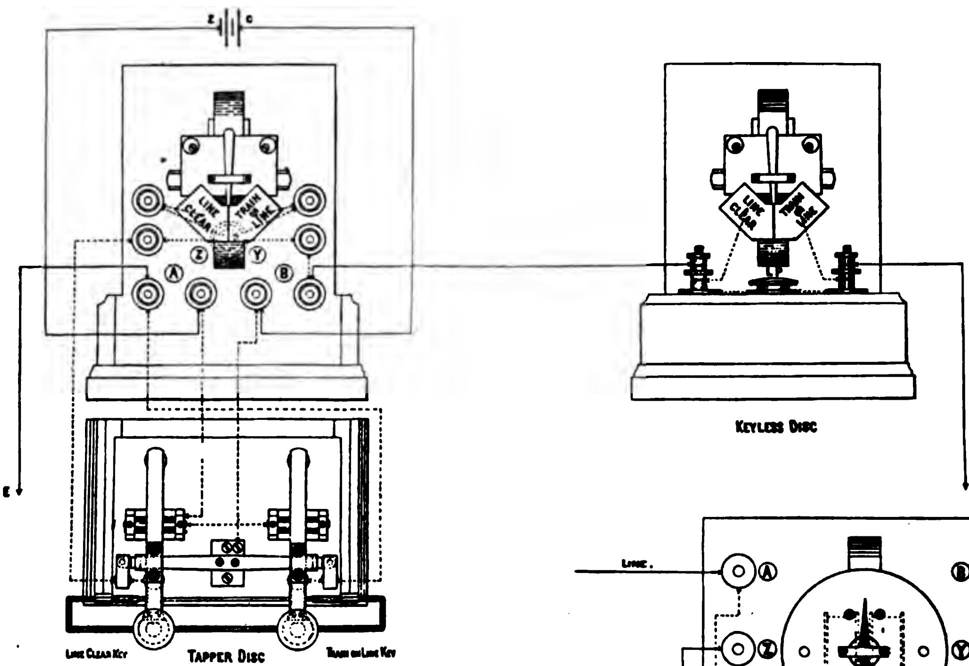


Fig. 238. Indicator Block Instrument, Great Western Railway of England.

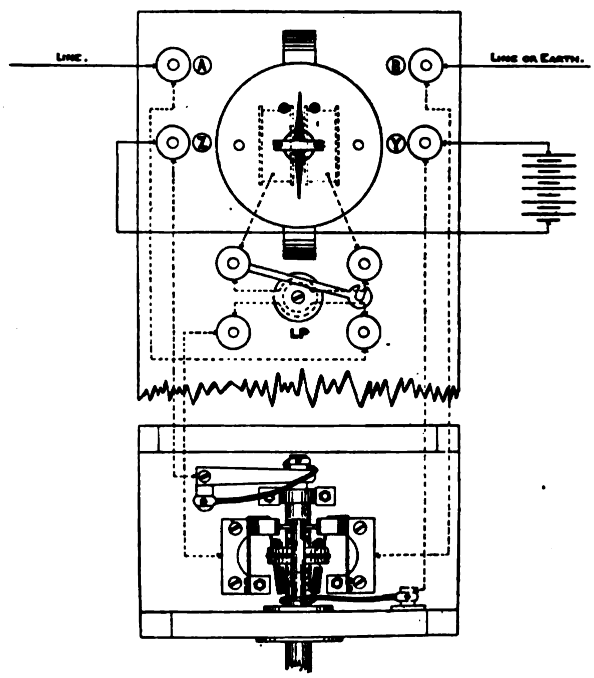
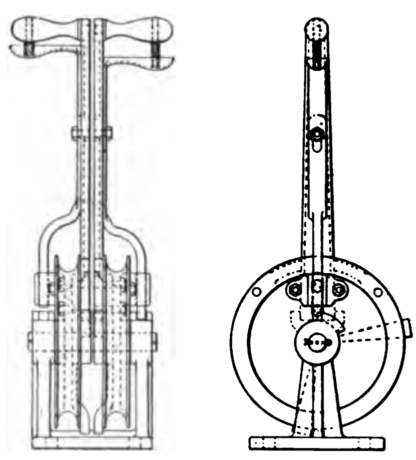


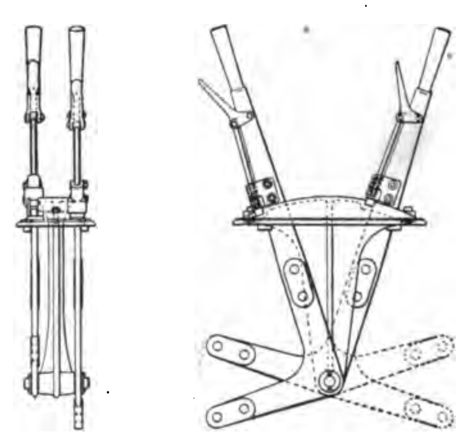
Fig. 239. Single Needle Block Instrument, Great Western Railway of England.

The block instrument commonly used in Great Britain for communicating between block stations is essentially a galvanometer, having a rotating armature mounted between two coils of wire. When current flows through the coils in one direction the armature tends to rotate to the right and when the direction of flow of current is reversed the armature rotates to the left. When no current flows, the armature returns to a neutral position in the center. The armature may carry a printed disk or indicator as in Fig. 238, or simply a needle as in Figs. 237 and 239. The needle instrument (Fig. 239) may be used as a speaking telegraph also, movements of the needle to the right or left corresponding to the dots and dashes of the Morse code. Sending is done by pressing down the "line clear" key or the "train on line" key (Fig. 238), or by turning the knob (Fig. 237), to the right or left. This reverses the polarity of the current by changing the connections of the battery between line and ground.

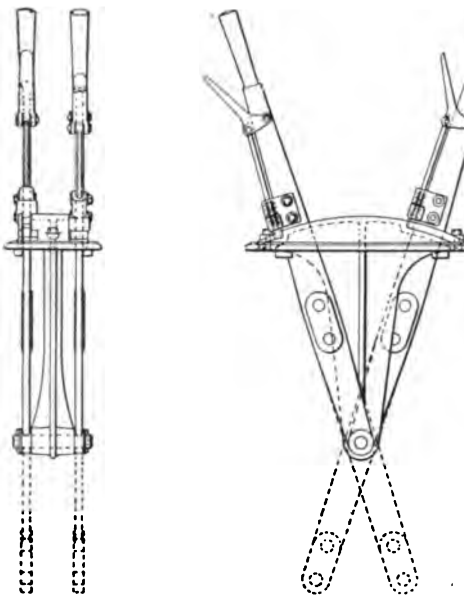
When a signalman, say at B, gives a "line clear" signal to the station in the rear, say A, he fastens his indicator in the "line clear" position, thus keeping before him a visual indication of what he has done. As soon as the station in the rear (A) reports the starting of the train the signalman at B puts his indicator in the position showing "train on line" and fastens it there. In like manner the signalman at B fastens his indicator, after sending any signal over the wire to C, thus having before him constantly a visual indication of the movement last made.



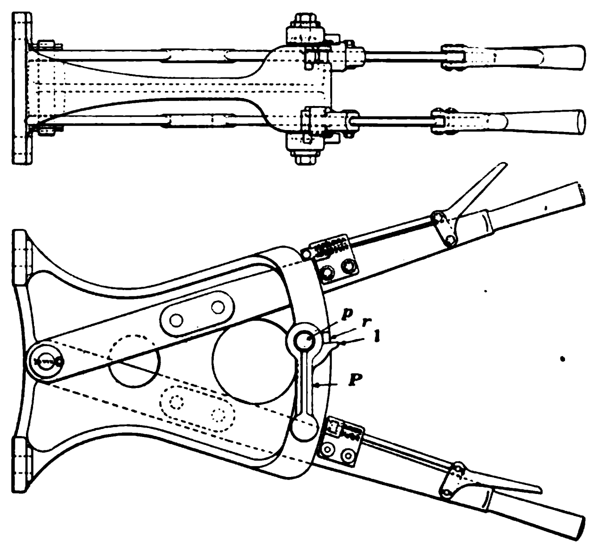
*Figs. 240-241. Signal Levers.—Two Lever, Two-Position Wall or Table Lever Machine with Chain Wheel Attachment.



Figs. 242-243. Signal Levers.—Two Lever, Two-Position Table Lever Machine for Vertical or Horizontal Pipe or Wire Lead-out. The Union Switch & Signal Company.



Figs. 244-245. Two-Lever Two-Position Table Lever Machine for Horizontal Pipe or Wire Lead-out. The Union Switch & Signal Company.



Figs. 246-247. Three-Position Horizontal Wall Lever Machine for Vertical Lead-out. The Union Switch & Signal Company.

The pendulum P lies normally in the vertical plane as shown; when the signal lever is returned from its lowest or clear position, its latch impinges on the lower side of the lug 1, rotating it around the pivot p, and past the center notch r, thus preventing the lever latch from falling into the notch. This compels the signalman to complete the travel of the lever and thus return the signal to "stop" before again clearing it. As soon as the lever has passed the center notch, the pendulum P falls back to its normal position by gravity.

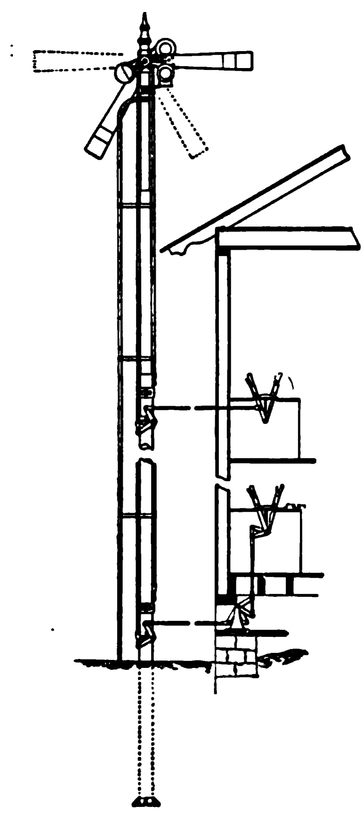


*Fig. 248. Vertical and Horizontal Pipe Lead-outs for Table Machines.

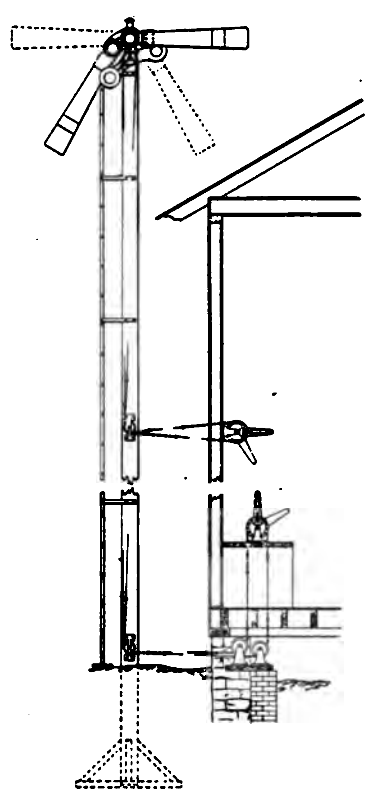


*Fig. 249. Chain Wheel and Wire Lead-outs for Wall and Table Machines.

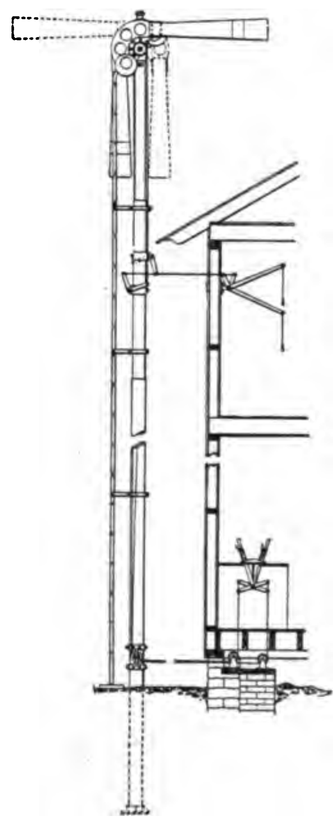


*Fig. 250. Vertical and Horizontal Wire Lead-outs for Wall and Table Machines.

Figs. 248-250. Typical Arrangements of Lead-out Connections from Manual Block Stations to Signals.

THE COLEMAN "LOCK AND BLOCK" SYSTEM

The Controlled Manual or "Lock and Block" instruments, made by the Union Switch & Signal Company, is an improved form of the Sykes instrument and accomplishes all and more than the original Sykes instruments which were imported from England. The Sykes system, as originally installed in the United States, used only one home signal and a distant signal at each block tower for each track. This arrangement is still used in many cases where there are no switches at or near the block tower. In practice, however, it often has been found convenient to use an advance block signal in addition to the home signal, in order to conveniently permit trains to use the switches situated between the home and the advance block signal, and to expedite the movement of trains from block to block when traffic is heavy. On the New York Central advance block signals have been installed at nearly all block towers where there are switches, and at some few other towers where there are no switches. Where no advance block signal is used the locking up track circuit and the plunger release track circuit are combined in one.*

Figs. 260-261 show the operation of the Coleman instruments for double track with home and advance block signals, as installed on the New York Central. In this installation the Advance or Starting Signal is known as the Block Signal. A train occupying track between signals H and B at tower X is to proceed to tower Y. The signalman at X calls Y by bell and asks for an "unlock." If the preceding train has cleared the block at Y and the instruments are normal as shown in the diagrams, and Y pulls out the plunger as far as it will go, thereby raising his banner to show "locked." This closes the contact shown below coil 46. To insure signal H at Y being blocked and the terminal block track circuit unoccupied, a preliminary circuit is provided from battery wire 101, through binding post 1, coil 46, coil 47, binding post 9, wire 17, contact 1 on home lever roller, wire 14, front contact on terminal block relay, to common return wire 100. If the two conditions are fulfilled this circuit is completed, energizing magnet 46 and holding up the banner to show "locked" by the latch of 46. Y then releases his plunger which is returned to its normal position by a spring. When the plunger completes its return stroke the latch shown back of the banner drops into a notch in the plunger bar (or slide) and locks it in the normal position, at the same time breaking the contact between 46 and 47. But before this contact is broken another contact is made between 46 and 10, thereby preventing the banner from falling. The plunger cannot again be pulled out until the banner has been returned to the normal, or "free" position. When the plunger completes its return stroke the circuit from Y is as follows: From 101 through 1, 46, 10, block wire 22 to block wire 23 at X, 6, block indicator 80, 5, 48, locking up relay contact to 100. A shunt circuit is also provided from 48 through 49 and contact 2 on block lever roller to 100, the purpose of which is explained below. **It should be remembered that the block wire numbered 22 at Y and 23 at X is a continuous wire. Indicator 80 clears when energized**

Fig. 251. Coleman Lock and Block Instrument. The Union Switch & Signal Company.

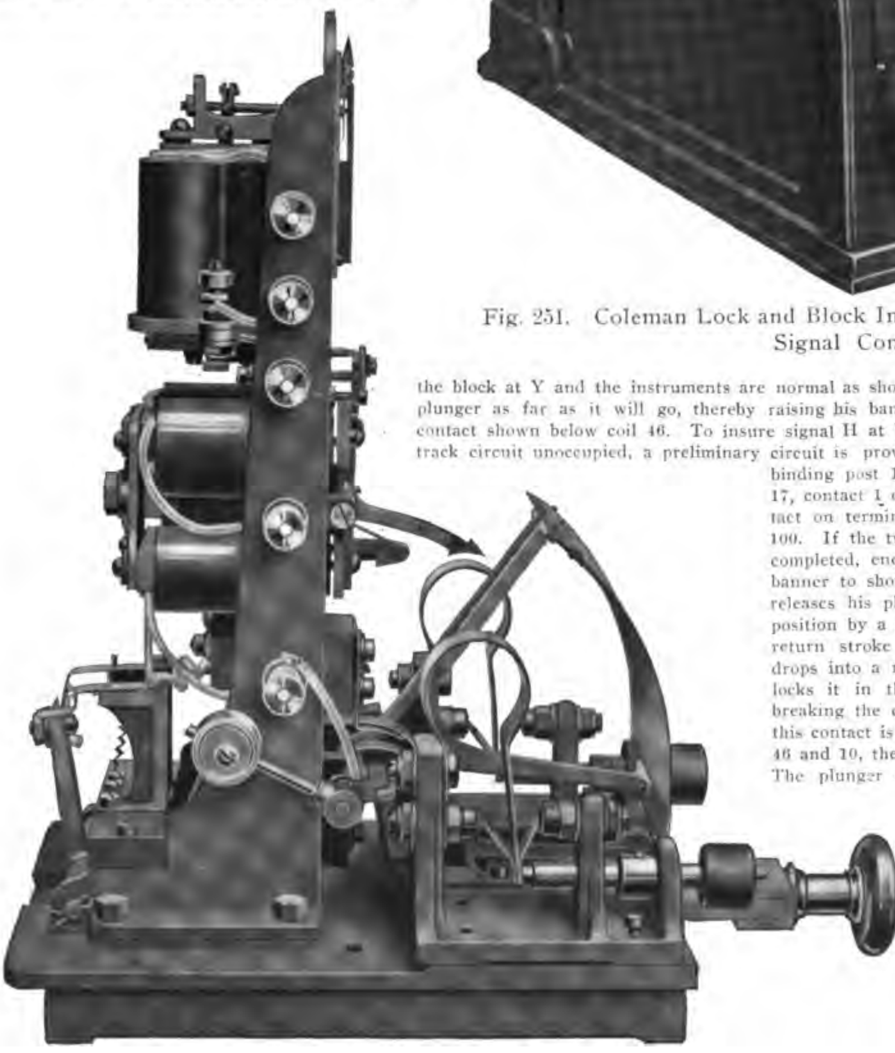


Fig. 252. Coleman Lock and Block Instrument; Side View, with Cover Removed.

*See definition of track circuit, and Figs. 826-870.

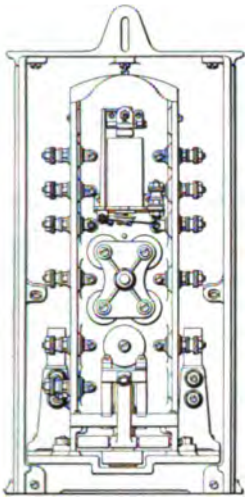


Fig. 253.

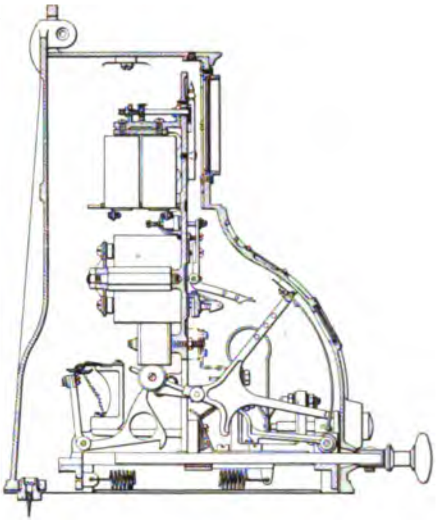


Fig. 254.

Figs. 253-255. Coleman Lock and Block Instrument; Parts in "Free" Position.

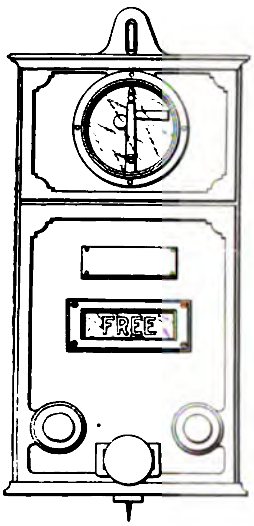


Fig. 255.

showing X that Y has given an unlock; contact on the armature of 80 is also closed. To clear the block signal B at X after the unlock is given, the circuit is from 101 at X through 4, contact on indicator 80 (which is now closed), 7, 87, floor push (which must be closed), 82, block lever lock magnet, to 100. This energizes the block lever lock magnet and unlocks the lever so that the signal B can be cleared. As soon as X clears signal B to permit train to proceed to Y, one shunt of the unlock circuit is broken at 2 on block lever roller between 49 and 100. The original circuit for the unlock, however, is still retained from 48 through locking up relay contact at signal B to 100. When the train enters the locking up track circuit beyond signal B, this second shunt circuit is also broken by the armature of the relay dropping and all connection between the two instruments at X and Y over block wire 22-23 is broken until X again restores signal B to stop or the train passes completely out of the locking up track circuit. As soon as the unlock circuit is broken the indicator at X is de-energized. The magnet 46 at Y is also de-energized and its latch armature swings away, allowing the banner to drop to the position "train in block" (catching on the bottom hook of latch 62). As the banner drops from the "locked" position, the contact below coil 46 opens, and energy from wire 101, which was connected to wire 22 through this part of the instrument, is now cut off.

As the train approaches Y, the signal H at Y cannot be cleared unless signal B is blocked and the track sections between signals H and B are unoccupied. This is provided for by the home lever lock which cannot be released to clear the home signal H except through the circuit 101, floor push (which must be closed), 13, home lever lock, 34, contact 1 on block lever roller, 35, home lock relay contact, 36, plunger release relay contact to 100. After the home signal H has been cleared and the train enters the plunger release track circuit, current flows from 101 through 2, 62, 8, 18, back contact on plunger release relay to 100. This energizes 62 and lifts the latch, allowing the banner to drop about ¼ in. to rest on the notch on the top of the latch of 62. The banner, however, still displays "train in block." As the train passes out of the plunger release track circuit the contact on plunger release relay is broken but 62 is still energized by current flowing through a shunt circuit from 101 through 2, 62, armature of 62, 3, 15, contact 4 on home lever roller (closed when signal is cleared) to 100. This current holds up the latch of 62 ("train in block" still displayed) until contact 4 is broken by returning the home signal H to stop behind the train. When the signalman has done this the latch of 62 drops and releases the banner which then falls to the "free" position. The banner in returning to the "free" position releases the latch holding in the plunger bar, and an unlock can then be given for forwarding another train from X to Y.

It will be seen that an unlock can be given by Y to X at any time provided signals B at X and H at Y are blocked, and the track between them is unoccupied. An unlock

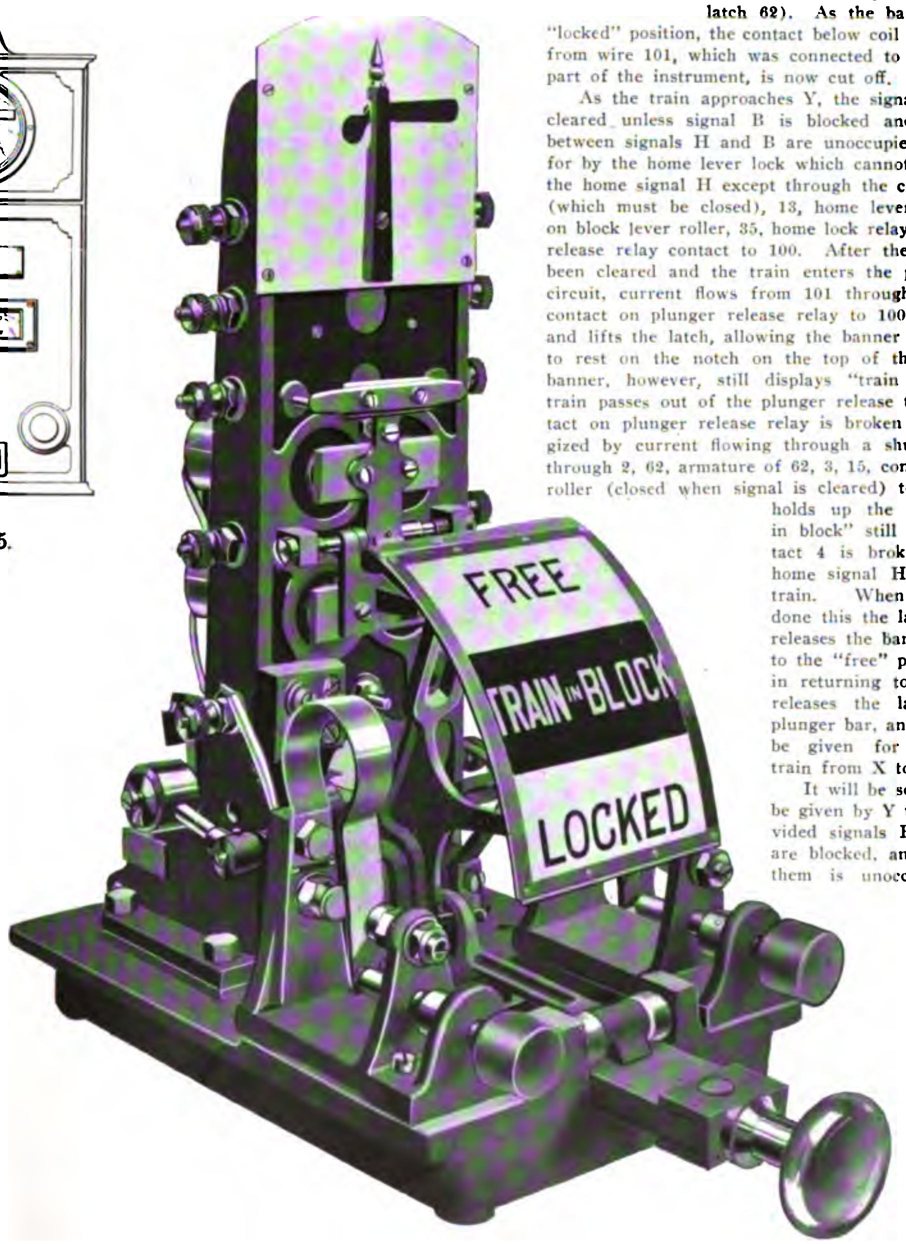


Fig. 256. Front View of Coleman Lock and Block Instrument with Cover Removed.

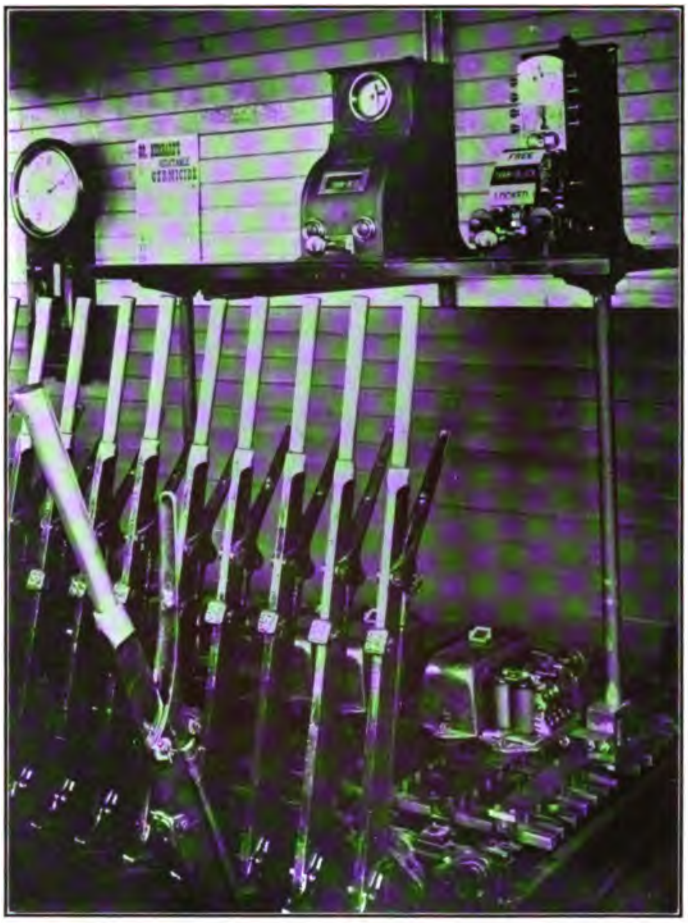


Fig. 257. Interior of Block Signal Cabin Showing Location of Lock and Block Instruments over Interlocking Machine.

once given may be held indefinitely until used. In practice, notice of the approach of a train is given some time before its arrival. X may clear home signal H at any time (the control of its block being the same as already explained for the corresponding signal at Y) before a train comes within sight of his distant signal X asks Y for an unlock and on receiving it clears signal B. With both the home and block signals cleared, the distant signal can then be cleared and the approaching train sent forward without slackening speed. After the train has passed signal B at X no other train can follow toward Y until the instrument at Y has been restored to its normal position by the passage of the first train over the plunger release track circuit at Y, and the home signal H at Y restored to the stop position.

In case the signalman at Y attempts to give X an unlock while a train is in the terminal track circuit section, or while his home signal is clear, the magnet 46, is de-energized and its latch will not hold up the banner which drops to "train in block" when the plunger is released. The signalman may then repeat the operation of plunging to give X an unlock any number of times, but until magnet 46 is energized and holds the banner in the "locked" position no current can flow from Y to X to unlock X.

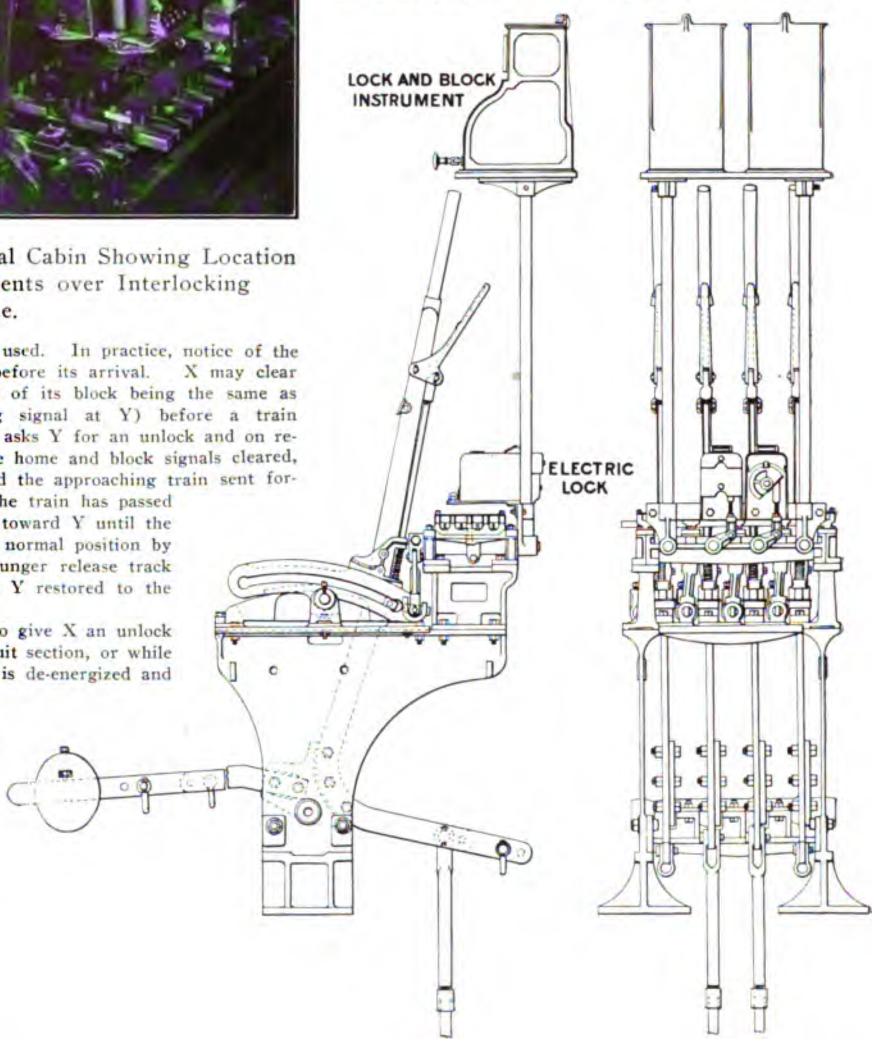
The floor pushes are for the purpose of economy in the use of battery.

The purpose of coil 47 is to introduce dead resistance in series with coil 46 while on local circuit, corresponding to the resistance of the block wire 22-23 and the indicator 80 at the next tower. Its use prevents excessive current from flowing through coil 46, which would tend to produce residual magnetism in that coil, and it also increases the efficiency of the main battery for use on other circuits.

The unlock shunt, wire 49, may be, and sometimes is, omitted. Its purpose is to provide a means of operating the instruments in case of failure of the locking up track circuit. It will be seen that if the circuit through 48 and locking up relay contact to 100 is broken (by failure of the relay or track circuit to operate properly) the unlock can still be given when necessary, and is taken away every time the block signal B is cleared to permit a train to proceed toward the next tower.

It is essential in any installation of these "controlled manual" instruments, that the first home signal be semi-automatic in its operation, going to the stop position automatically as soon as a train has passed. If this arrangement is not made the signalman at the entrance of the first block, having received an unlock from the next tower in advance, might leave his signals in the clear position; the second signalman could in turn do likewise and so on. Thus continuous clear signals could be displayed throughout the entire installation, for any number of successive trains.

Where switches operated from the tower are installed between the home signal H and the block signal B, a switch box is usually arranged to shunt the home lock track circuit relay when the switch is open, and thus prevent the home lever lock from being energized, as already explained. This is a precaution in addition to the mechanical locking between the switch lever and the home signal lever in the tower, and is valuable in case the mechanical connections to the switch should become disconnected while the switch was open, thus allowing the switch lever to be returned to normal, and the home signal cleared while the switch remained open. For arrangement of circuits with non-interlocked outlying switches, see Figs. 264-269.



Figs. 258-259. Application of Electric Locks and Method of Mounting Instruments on Saxby & Farmer Interlocking Machine.

NOTE.—The vertical pipe shown back of the signal lever is simply a support for the shelf on which the lock and block instruments are mounted. There is no mechanical connection between the lock and block instruments and the locking rods or electric locks on the interlocking machine below.

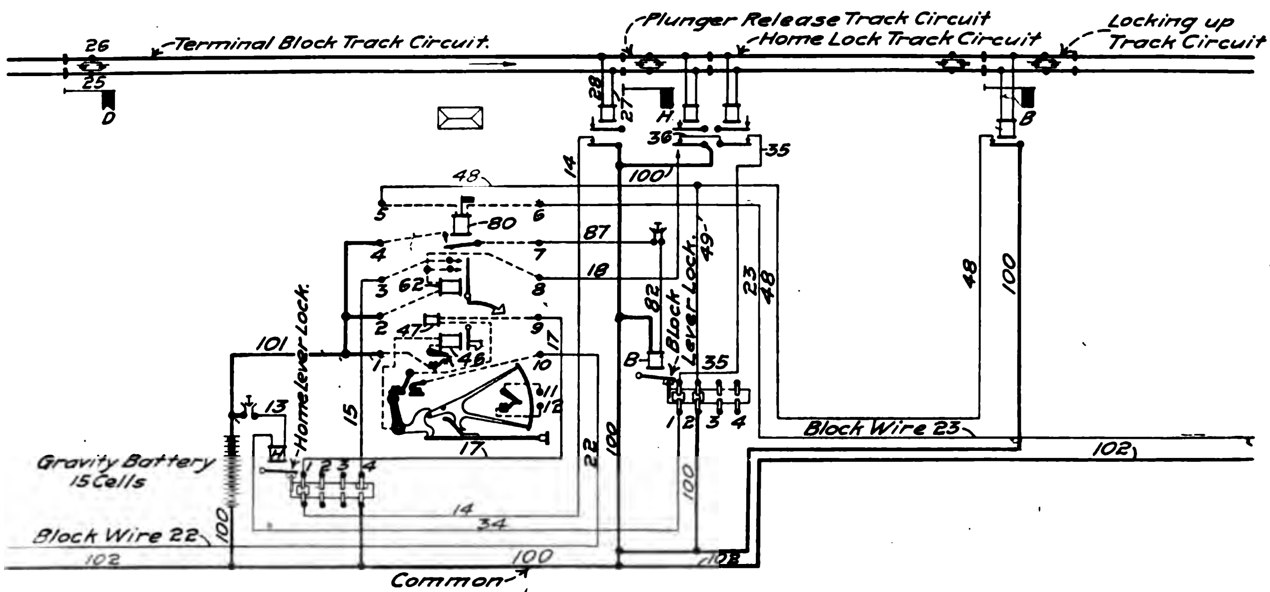


Fig. 260. Standard Circuit Plan for Controlled Manual Signals, with Non-Continuous Track Circuit. New York Central.

This plan is referred to in description as "Tower X."

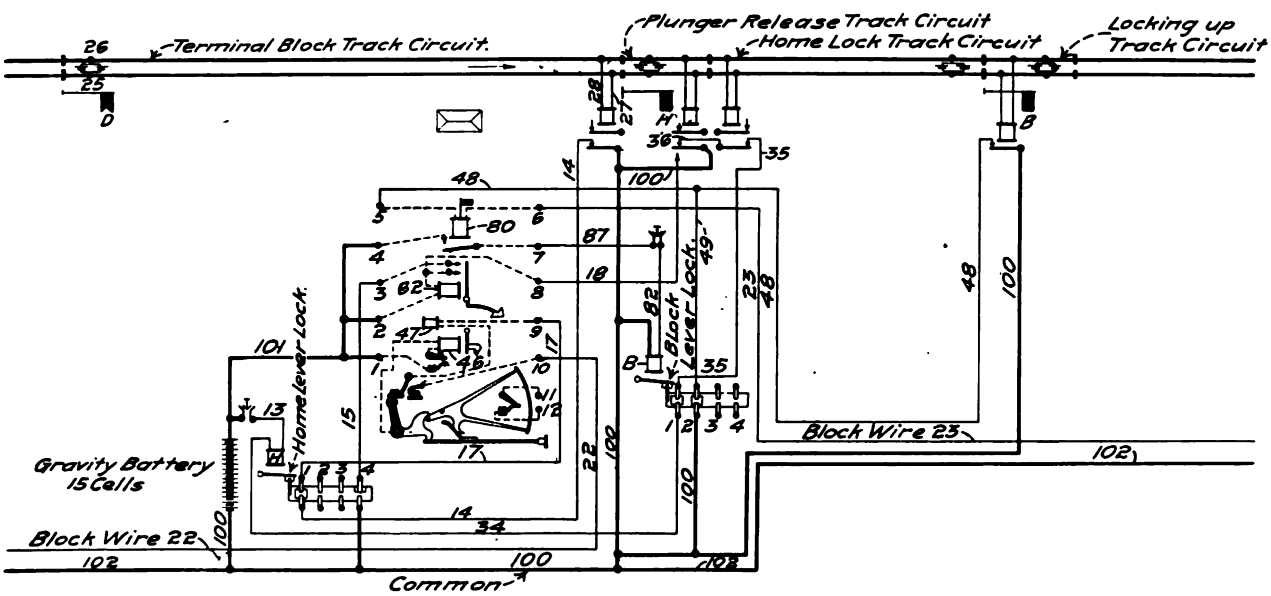


Fig. 261. Standard Circuit Plan for Controlled Manual Signals, with Non-Continuous Track Circuit. New York Central.

This plan is a duplicate of Fig. 261 and is referred to in the description as "Tower Y."

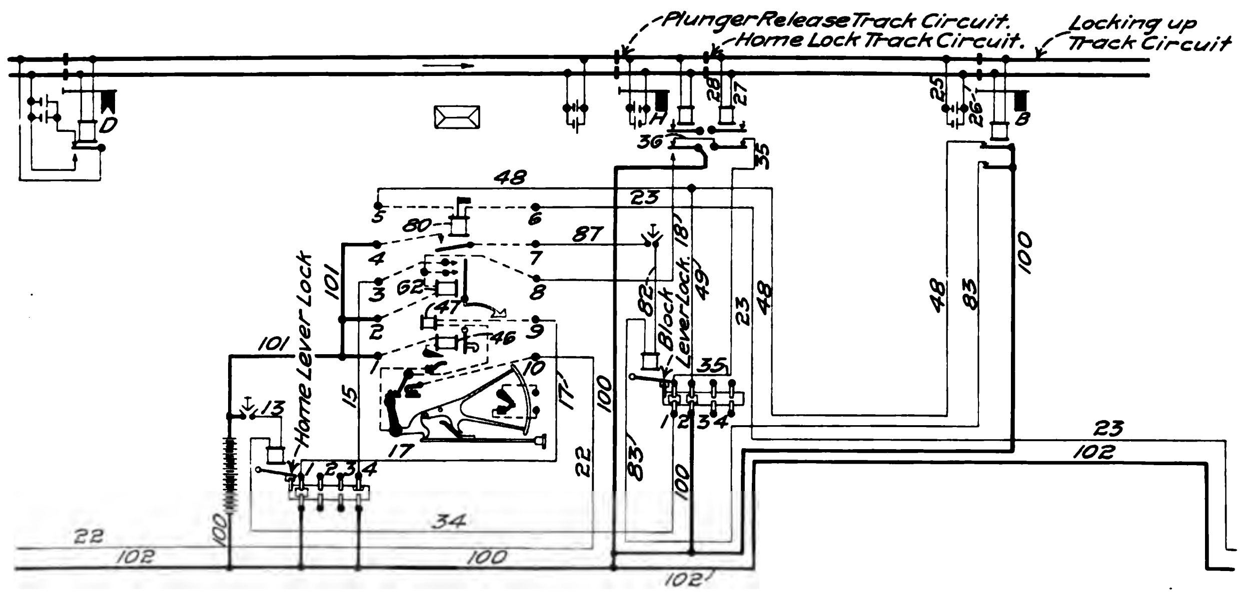


Fig. 262. Circuits for Controlled Manual Signals, with Continuous Track Circuit. New York Central & Hudson River Railroad.

The controlled manual system described in connection with Figs. 260-261, provides protection against every possibility of collision between trains except in case of a train breaking in two between X and Y, leaving one or more cars in the block. The signalman at Y, unless he carefully observes the rear end train markers, may give an unlock to X after part of a train has passed out of the block while the rear cars are standing somewhere between the towers. In order to give protection against this possible danger a continuous track circuit may be employed between signal B at X and signal H at Y. Such an arrangement is shown in Fig. 262. In effect the locking-up track circuit at X is extended through the block and is relayed through the terminal block track circuit at Y. An additional contact is added to the track relay of the locking-up track circuit at signal B and the circuit which unlocks the block lever is carried through it as follows: From battery wire 101 to binding post 4, contact on armature of indicator 80, bending post 7, wire 87, floor push (which must be closed), wire 82, block lever lock magnet, wire 83, front contact on locking-up track circuit relay, to common wire 100. The block lever lock cannot be released to clear signal B as long as the track section between signal B at X and signal H at Y is occupied. Protection is also afforded against broken rails, since a break would de-energize the locking-up relay and open the contact in the unlocking circuit, thereby preventing signal B from being cleared. The only other difference between the other circuits shown in Fig. 262 and those shown in Figs. 260-261 is that the preliminary circuit, required before an unlock can be given, is carried direct to common wire 100 from contact 1 on home signal lever roller instead of through contact on terminal block relay.

The shunt circuit for the unlock through wire 49 and contact 2 on the block signal lever roller to common wire 100 is retained, but for a different purpose from what was explained in connection with Figs. 260-261. It is needed here in case a train has to pass signal B for switching purposes. If the signalman had obtained an unlock and should allow a train to pass signal B, without wire 49, he would lose his unlock as soon as the train entered the locking-up track circuit. But by keeping signal B blocked, and giving the train permission to pass it in that position (for switching purposes only), he saves his unlock to use when they are ready to depart, and thus avoids issuing a caution card which would otherwise be necessary in order to permit them to proceed.

The object in putting in a cut section at the distant signal D

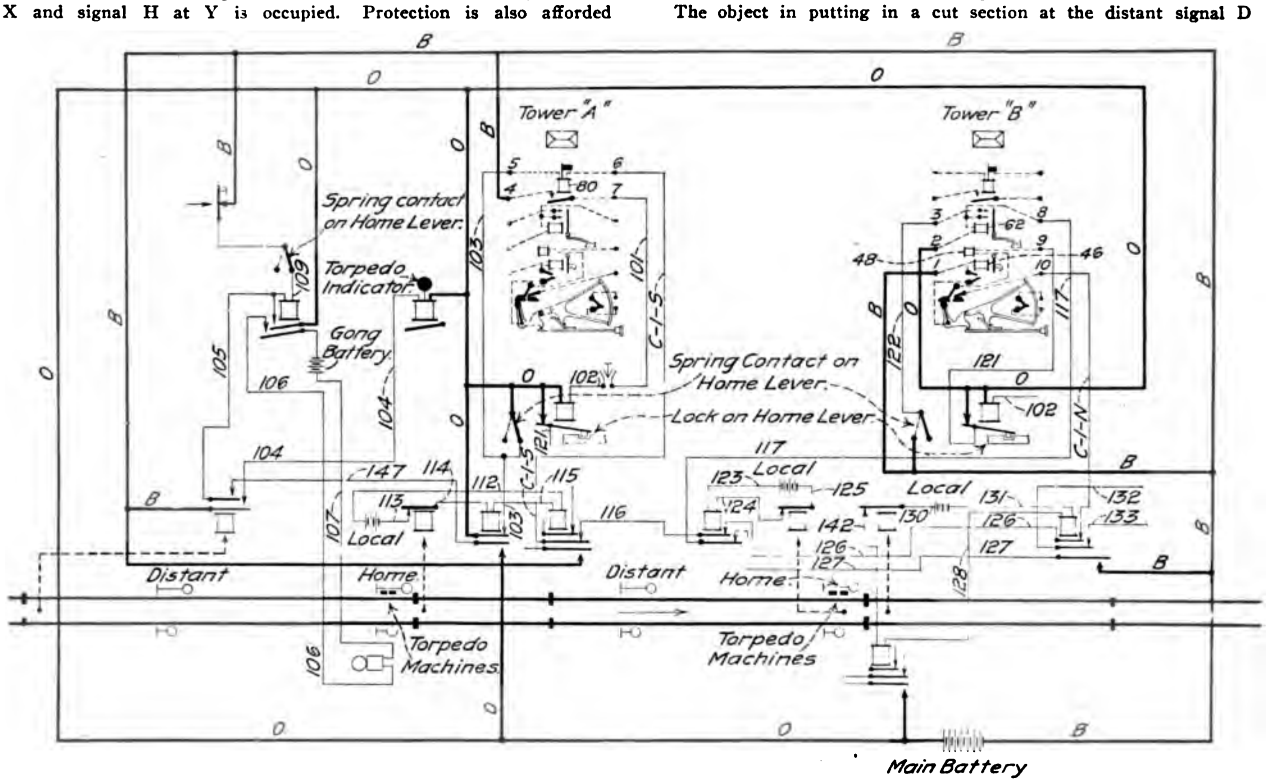


Fig. 263. Circuits for Controlled Manual Signals in Park Avenue Tunnel of the New York Central, New York City; Continuous Track Circuit, Overlaps, Torpedo Machines and Alarm Gongs, but no Advance Block Signals.

and relaying the locking-up track circuit through it to signal H, is to simplify the connections in case it is desired to put in an outlying switch between signals D and H, or to make D a semi-automatic signal.

In Fig. 263 the plunger release track circuit and the locking-up track circuit are combined, as stated on page 20, and lengthened to form an overlap section in advance of the home signal. In this explanation the relay controlled by the track circuit of this overlap section will be termed the overlap relay, and the relay in the track circuit extending from the home signal back to the next overlap section in rear will be termed the terminal block relay. For tower B to give tower A an unlock the preliminary circuit is from battery to b. p. 1, through instrument to b. p. 9, wire 121, back contact on home lever lock to common wire O. The home signal must, therefore, be locked in the stop position. The unlocking circuit is from battery to b. p. 1, through instrument to b. p. 10, wire C-1-N, front contact on relay, wire 126, front contact on relay, wire 116, front contact on relay, wire C-1-S to b. p. 6 at A, through block indicator 80 to b. p. 5, wire 108, front contact on relay to common wire O; or from wire 108 through spring contact on home lever, normally closed, to common wire O. The first relay in this circuit is energized by local battery through front contact on overlap relay; the overlap section must be unoccupied and overlap relay energized in order to make contact on local relay. The second relay in the circuit is energized by local battery through front contact on terminal block relay. The third relay is similarly energized through front contact on overlap relay at A, and the last relay, between wire 103 and common, is also energized through front contact on overlap relay at A. The overlap section at B and the entire track section between home signals at A and B must be unoccupied in order to give an unlock. When unlock has been received at A the circuit is from battery to b. p. 4, contact on indicator 80, b. p. 7, wire 101, floor push (which must be closed) wire 102, home lever lock magnet to common wire O. The home signal at A can be cleared as soon as the home lever lock magnet is energized. As soon as the train enters the overlap section beyond the home signal at A, the overlap relay is de-energized and the unlock circuit is broken by the relay between wire 103 and common. This locks the instrument at B in "Train in Block" position. In case the relay between wire 103 and common does not act properly contact is broken on the unlock circuit by the spring contact on home lever at A which is opened when home signal at A is cleared. As soon as the train has cleared the overlap section at B all relays are again energized, the block instrument at B returns to normal and another unlock may be given.

Torpedo machines are installed at the home signals and are operated with the home signal lever. In order to warn the operator at A not to block the home signal and put torpedoes on the track before the train has passed entirely beyond the home signal a contact is added to the terminal block relay in rear of home signal at A, and current flows from battery through back contact on this relay, wire 104, and through a torpedo indicator to common wire O. This indicator is energized until every pair of wheels in the train has passed into the overlap section beyond the home signal and torpedo machine. The operator does not return the home lever to stop until the torpedo indicator clears.

If for any reason a train runs by the home signal at A in the stop position a loud gong begins to ring. As soon as the first pair of wheels enters the overlap section while the rear wheels are still in the terminal block section in rear of the home signal, both the terminal block relay and the overlap relay are de-energized. This closes the circuit from battery through spring bell key closed, through spring contact on home lever (closed when signal is in stop position), wire 109, stick relay, wire 105, back contact on terminal block relay, wire 147, back contact on relay to common. The stick relay is energized and current flows from gong battery through wire 107, gong wire 106, front contact on stick relay to battery. The gong continues to ring until the operator at A opens the spring key and allows the stick relay to drop.

Fig. 264. Two-Lever Dwarf Interlocking Machine with Electric Locks, Controlled from a Block Station.

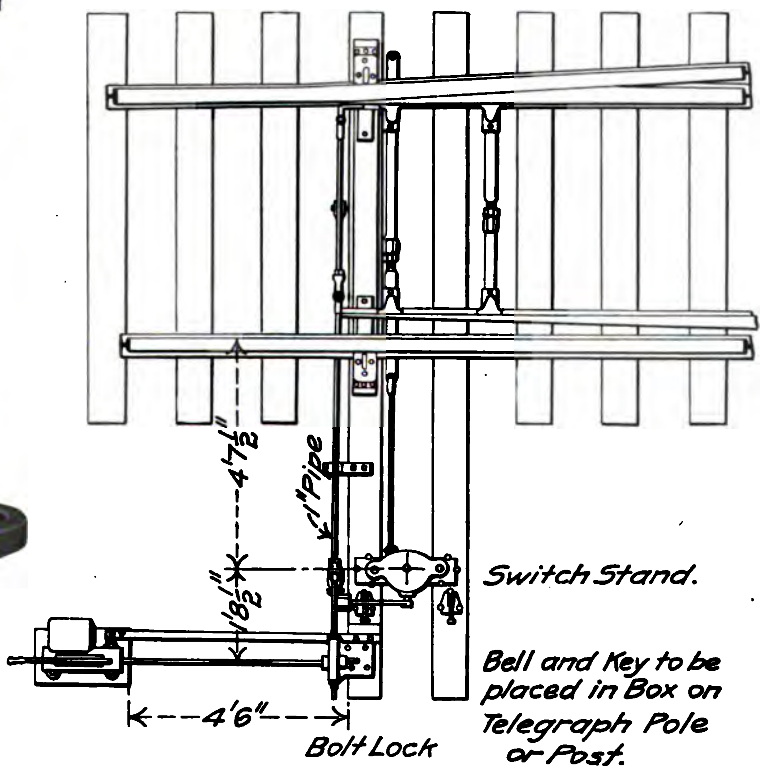


Fig. 265. Hand Switch, Bolt Locked by Dwarf Machine. New York Central & Hudson River.

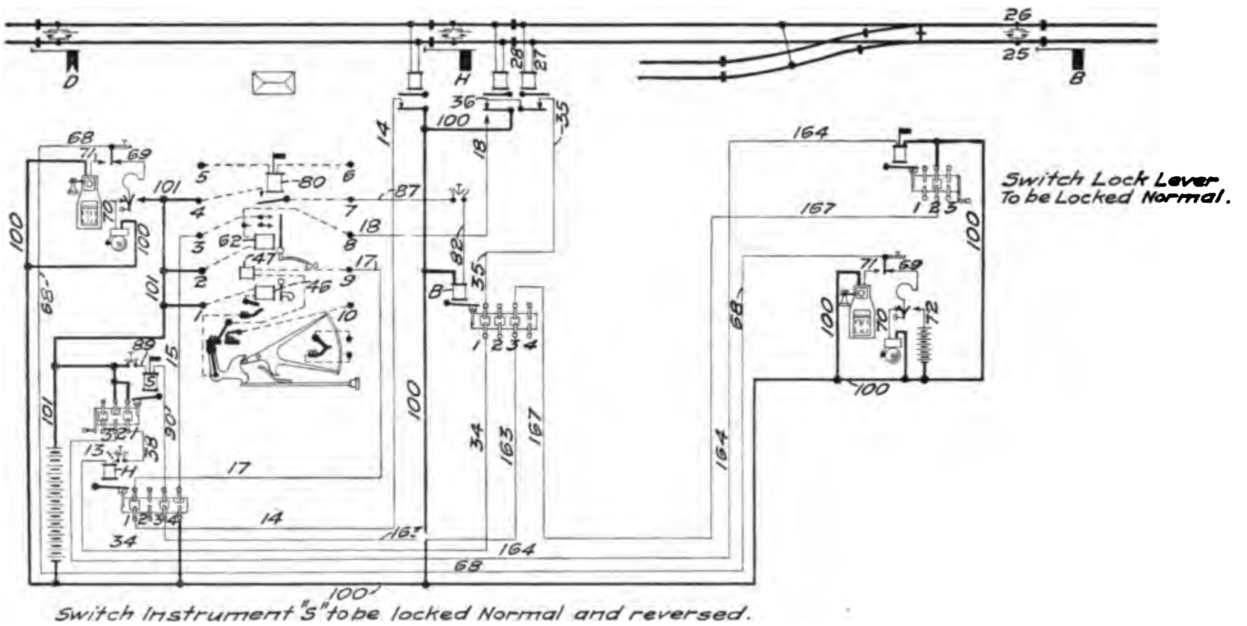


Fig. 266. Circuits for Controlled Manual Block Signals, with Non-Continuous Track Circuits and Outlying Switch between Home and Advance Signals. New York Central & Hudson River.

Fig. 267. Electric Lock with Semaphore Indicator. The Union Switch & Signal Company.

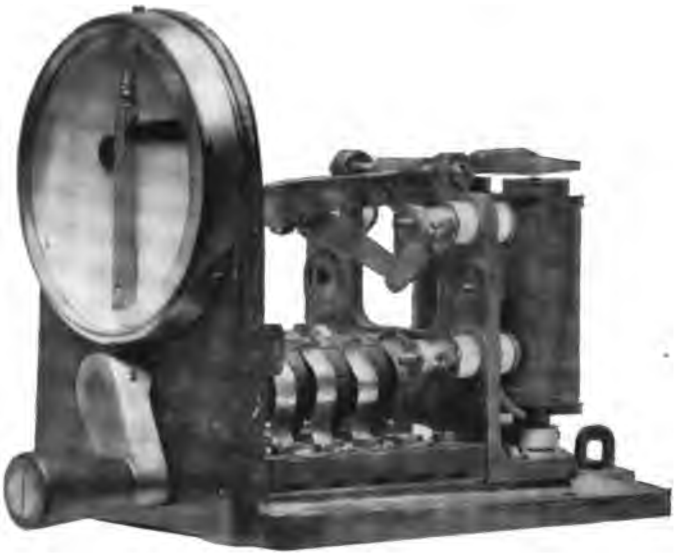


Fig. 268. Electric Lock Shown in Fig. 267, Cover Removed.

Figs. 264-269 show the method used in controlling main line switches which are situated too far away from towers to be interlocked. Such switches are operated by hand and are known as Outlying Switches. They are electrically locked and controlled by the signalman in an adjacent tower. The arrangement shown in Fig. 264 would cover two separate switches, one lever and one lock for each. The lever mechanically bolt-locks the switch in its normal position, and is in turn interlocked with the roller and segment of the electric lock. A switch lock controller, Figs. 267 and 268, is placed in the tower and connected, as shown in the wiring diagrams. Communication by bell code and telephone is also provided.

Fig. 266 shows the arrangement for an outlying switch between the home and advance signals and may be used with either continuous or non-continuous track circuits. The controller in the tower is locked in either normal or reverse position when its magnet, S, is de-energized. To permit a train standing between the switch and signal B, to use the switch, the signalman closes the floor-push from battery wire 101 to wire 89, completing the circuit through coil S, wire 90, contact 3, on home lever roller, wire 163, contact 3, on block lever roller, wire 167, and contact 2, on switch lock roller to common return wire 100. This circuit, if complete, ensures that both the home and advance signals are in the stop position, and also that the switch lock is normal. The signalman then reverses his controller, opening contact 1, which locks the home signal lever normal, and closing contact 2, which completes the circuit from 101 through wire 164 and switch lock magnet to 100, unlocking the switch lock, which must be reversed by the trainman before he opens the switch. When he reverses this roller contact 2 is opened, breaking connection between wire 167 and 100, and de-energizing magnet S, which then locks the controller in its reversed position. The train may now use the switch, and, if necessary, may clear the main track entirely to allow one or more trains to pass. In case it is desired to do this the trainman, after closing the switch and locking it for the main track, restores the switch lock to its normal position, closing contact 2 on its roller. This again completes the circuit through magnet S (as already described), and the controller may then be returned to its normal position by the signalman. He must do this before he can clear signal H, because, as already stated, the circuit for lever lock H is carried through contact 1 on the switch lock controller and is closed in its normal position only. When he reverses signal H to allow a train on the main track to pass over the switch, he breaks the connection between wire 90 and wire 163, locking controller S normal.

Having received an unlock from the next tower in advance, as already described, he then clears signal B and allows the main line train to proceed. After it has passed he must restore signal B to the stop position before he can unlock the outlying switch, because the circuit for magnet S is carried through a normal contact (3) on the block lever roller. This arrangement prevents him from permitting the train, coming out of the siding, to follow the other into the block without getting another unlock, which might otherwise be done.

The controller may now be operated, the switch unlocked and used and the controller restored in the same manner as before.

An outlying switch between block signal at one tower and distant signal at tower in advance is locked and controlled by the signalman in the tower in rear, by means of the switch lock controller shown in Fig. 269. This controller is locked in either normal or reverse position when the magnet S is de-energized. The preliminary and unlock circuits are the same as already described, except that wire 49 is continued through roller on block lever to roller contact 5 on the switch lock controller and thence to common return wire, 100; a relay, K, is also introduced controlled through wires 87 and 81, by indicator 80. A train having passed the signal B, and wishing to use the outlying switch on arrival, stops and stands on the lock-releasing track circuit. Communication is established by bell key and telephone with the tower in the rear, and an unlock for the switch is asked for. The circuit for unlocking the switch controller at the tower is as follows: From battery wire 101, through lock magnet S, wire 89, floor push, wire 90, contact 1 on switch lock controller, wire 85, contact 4 on block lever roller, wire 86, of switch lock L (now closed), wire 58 and roller contact to 100. The switch lock controller in the tower is then restored to its normal position, and by opening roller contacts 2 and 3 it locks itself and the switch lock L in the normal position. Any number of trains may now be sent through the block in the usual manner.

When the train in the siding wishes to again take the main track it is necessary for the tower in advance to give an unlock to the tower in rear, all signals being in the stop position. This energizes the relay K through wire 81, making a front contact for wire 86 and permitting the switch lock controller to be unlocked through the following circuit: Battery wire 101, lock magnet S, wire 89, floor push, wire 90, contact 1, wire 85, contact 4, wire 86, front contact (now closed) on relay K to common. The switch lock controller is then reversed, unlocking the switch lock roller. When the switch lock roller is reversed to unlock the switch, in order to allow the train to take the main line, a local indicator circuit is made up as follows: From 2-cell "SS" battery through

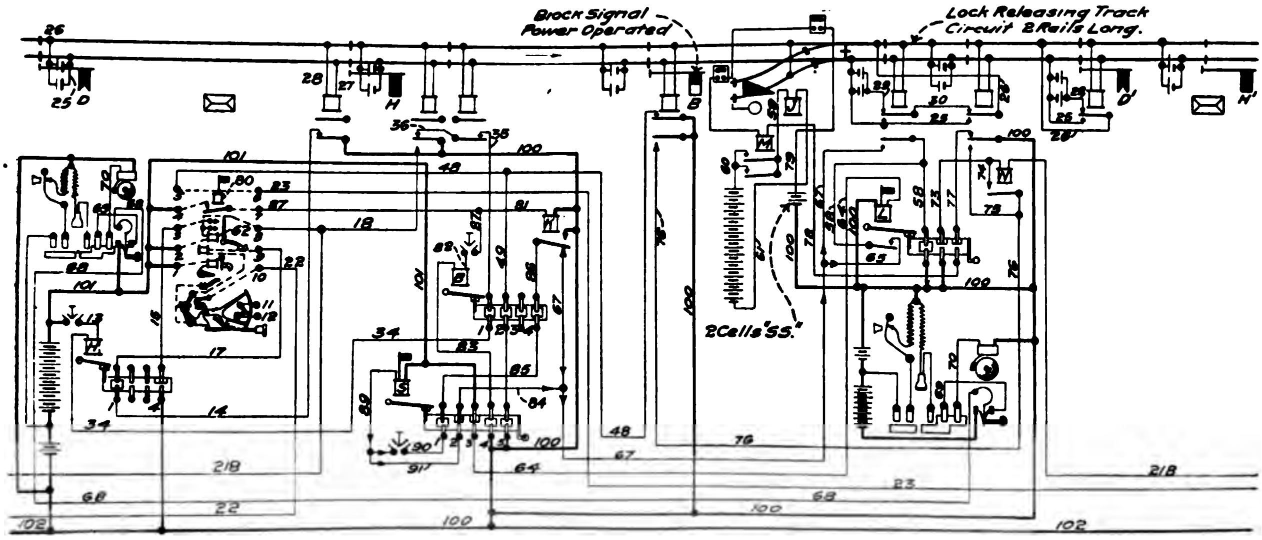


Fig. 269. Circuits for Controlled Manual Block Signals with Continuous Track Circuits and Outlying Switch Between Two Block Stations. New York Central & Hudson River.

back contact on relay K, wire 67, back contact (now closed) on lock-releasing circuit relay, wire 58, contact on switch lock roller to 100. This unlocks the switch lock controller in the tower, which is then reversed, opening contacts 1, 4 and 5 and closing contacts 2 and 3; opening contact 4 locks signal B in the stop position. Current then flows from wire 101, through contact 3 on switch lock controller, wire 64 to switch lock magnet L to 100. This unlocks the switch lock roller, which must be reversed to unlock the switch, being mechanically interlocked with same. As soon as this roller is reversed the connection of wire 58 to 100 is broken and lock magnet S is again de-energized, locking the switch lock controller in the reverse position. Also, when the switch lock roller is reversed, contact is made from wire 73 to 100, and this completes a circuit from battery at the block station in advance, through b. p. 2, magnet 62, of the block instrument, b. p. 8, wire 18, wire 218, "stick" relay N, wire 73, contact on switch lock roller to common. This permits the banner in the instrument at the advance block station, which now shows "train in block," to drop to the second latch of that position. The relay N will remain energized if a car is allowed to remain standing on the track anywhere between signal B and signal H' through a "stick" connection with back contacts on the relays controlled by this section of track (wires 75 and 76). If the train entirely clears the main line in taking the siding, the switch is thrown and then locked in the normal position by restoring the switch lock roller to normal, the contact of wire 73 is again broken and if the signal H' is in the stop position the banner at the tower in advance drops to the "free" position. Roller contact between wires 58 and 100 (which was broken) is now closed and the switch lock controller magnet S is energized through circuit as follows: From 101, through coil S, wires 89 and 91, roller contact 2 (now closed) wires 84, 67 and 65, contact operated by armature wire 79, switch boxes, relay M, wire 78, contact on switch lock roller (now closed), wire 77, front contact on track relay to wire 100. If this circuit is made up it insures that the track section between the switch and the home signal in advance is clear; relay M is energized and current flows from local battery, through wire 60, contacts on M, wire 59, indicator magnet J, wire 61 to battery. This indicator when energized shows "clear" and permits the train to leave the siding. After the train is again on the main line the switch is returned to normal and locked by the switch lock roller being restored to normal position, and controller S is unlocked and restored as already described. It is also necessary that the block instrument at the tower in advance be allowed to drop to the position "train in block." This is done by a combination of two circuits which drops the banner from "locked" past the first notch of the "train in block" position to the second notch, as follows: Reversing the switch lock controller at the tower in the rear cuts the circuit of wire 49. As soon as the train passes the fouling point in going out of the switch it de-energizes the locking-up relay at B, thus cutting wire 48. But before this occurs contact is made in reversed position of the switch lock roller for wire 73, thus causing current to flow from battery at tower in advance, through block instrument wire 218, stick relay N, wire 73 to common. As soon as the train enters the fouling section the banner drops from the "locked" position to the "train in block" position, but the circuit made up through 218 has energized magnet 62 and permits it to pass the first notch, catching it on the second. As soon as the train passes the home signal H' at the tower in advance, the plunger release track circuit and the home signal lever at that point restore the instrument to its normal position in the usual manner.

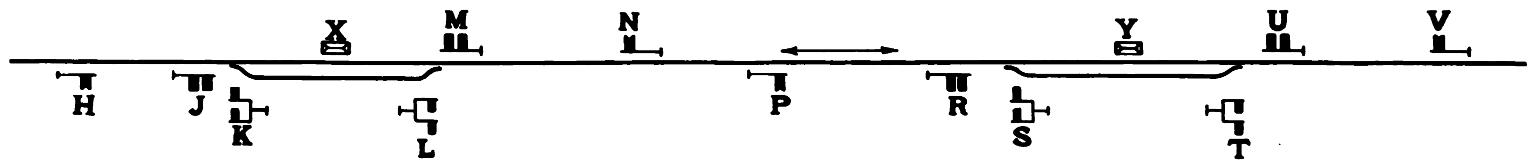


Fig. 270. Arrangement of Signals and Sidings for Controlled Manual on Single Track. Norfolk & Western.

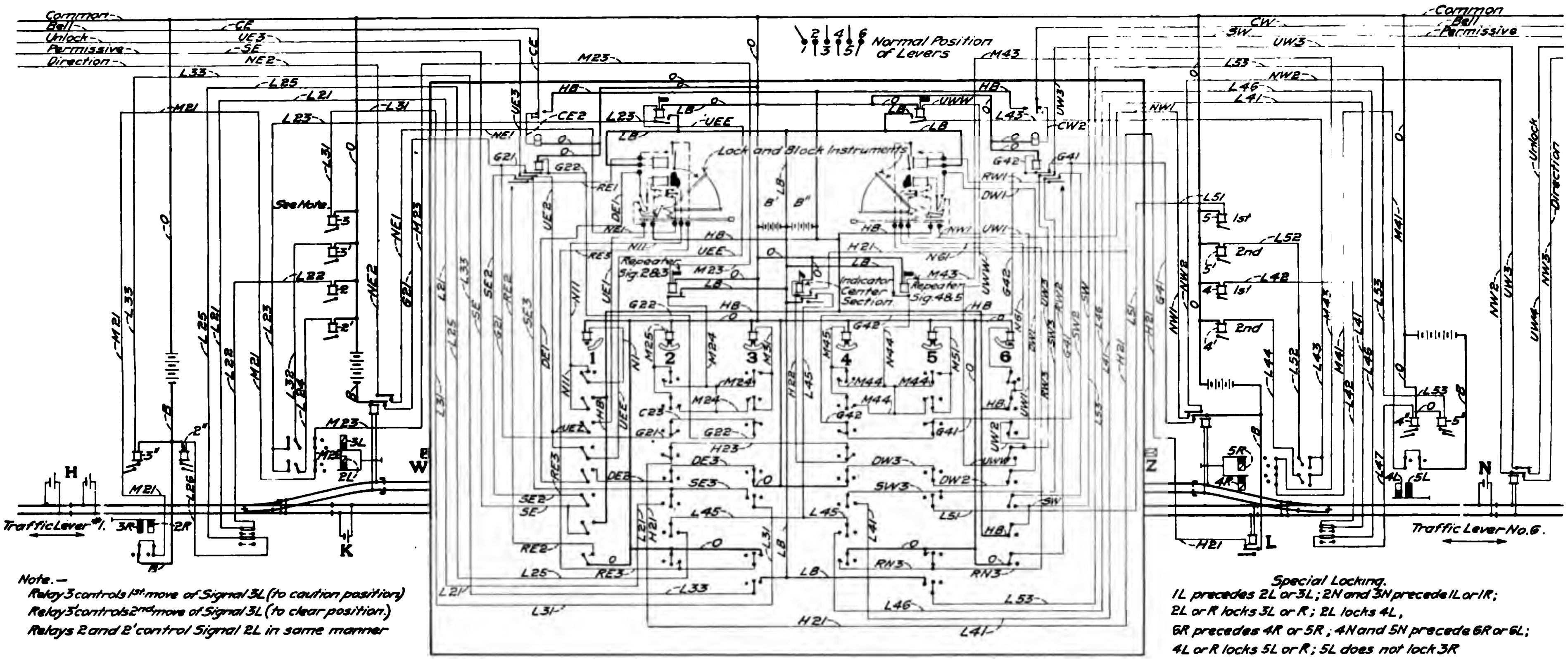


Fig. 271. Circuit Plan of Wiring and Instruments at Tower X; Norfolk & Western Single Track Controlled Manual.

This plan joins at N with P in Fig. 272 on opposite page.

The arrangement of sidings and signals for the application of the Union controlled manual or lock-and-block apparatus to single track is shown in Fig. 270. Home signals J, M, R and U are necessary, and in addition advance signals K, L, S and T. The advance signals allow one train to stand on the main line at a station between passing siding switches while other trains are approaching from either or both adjacent stations, the stationary train being on a track section not affecting the lock-and-block apparatus. The lock-and-block section extends from L at station X to S at station Y. For traffic from X to Y section L-N is the locking-up section and P-S the release section. When the direction of traffic is reversed from Y to X the function of these track sections is reversed.

At each block station a six-lever, electro-pneumatic type inter locking machine is installed to control by interlocked levers the signals at that point, the signals being operated by motors; the switches are thrown by hand. The necessary selective devices are applied in the signal circuits in addition to the mechanical locking in the machine. For each block, as L-S, one lever in each of the machines at X and Y is used as a direction controller to establish, maintain and prevent improper changing of the direction of traffic. In order to change the direction of traffic the advance signals, L and S at X and Y, respectively, must be in the stop position; track sections L-N, N-P and P-S must be free of trains; and lock and block instruments must show free, no trains being in the block and no unlock having been given. The lock and block instruments, one at X and one at Y for the block L-S, are controlled by these direction controller levers.

Referring to Figs. 271 and 272, the direction controlling levers, 1 and 6, are electrically locked circuit controllers and the levers point toward the direction of traffic established. For example, the circuits are shown for a direction of traffic established from tower Y to tower X. Lever 1 of the machine at Y points to the left toward X. Lever 6 of the machine at X points in the same direction, away from Y. To change the direction of traffic from Y toward X, to X toward Y, on notification, the signalman at Y moves lever 1 to the right. This establishes a circuit from battery at X through contact on lever 6 to wire N-61, through right-hand lock-and block instrument, wire N-W-1, front contact on relay, wire N-W-2, front contact on track relay N-P, direction wire N-W-3, to direction wire N-E-2 at Y, front contact on relay, wire N-E-1, left-hand lock-and-block instrument at Y, wire N-11, middle contact on lever 1, lever lock on 1 to common. This unlocks lever 1 so that the stroke can be completed. In order that this circuit can be complete the following conditions must be fulfilled: (1) Levers 4 and 5 normal and, therefore, signals 4 and 5 in the stop position (see special locking); (2) direction controlling lever 6 at X moved to the left as far as it will go; (3) lock and block instruments at both X and Y in the free position, showing no unlock given or train in block; (4) track sections L-N, N-P and P-S unoccupied. With these conditions fulfilled the lock on lever 1 at Y is released and the operator can complete the stroke to the right.

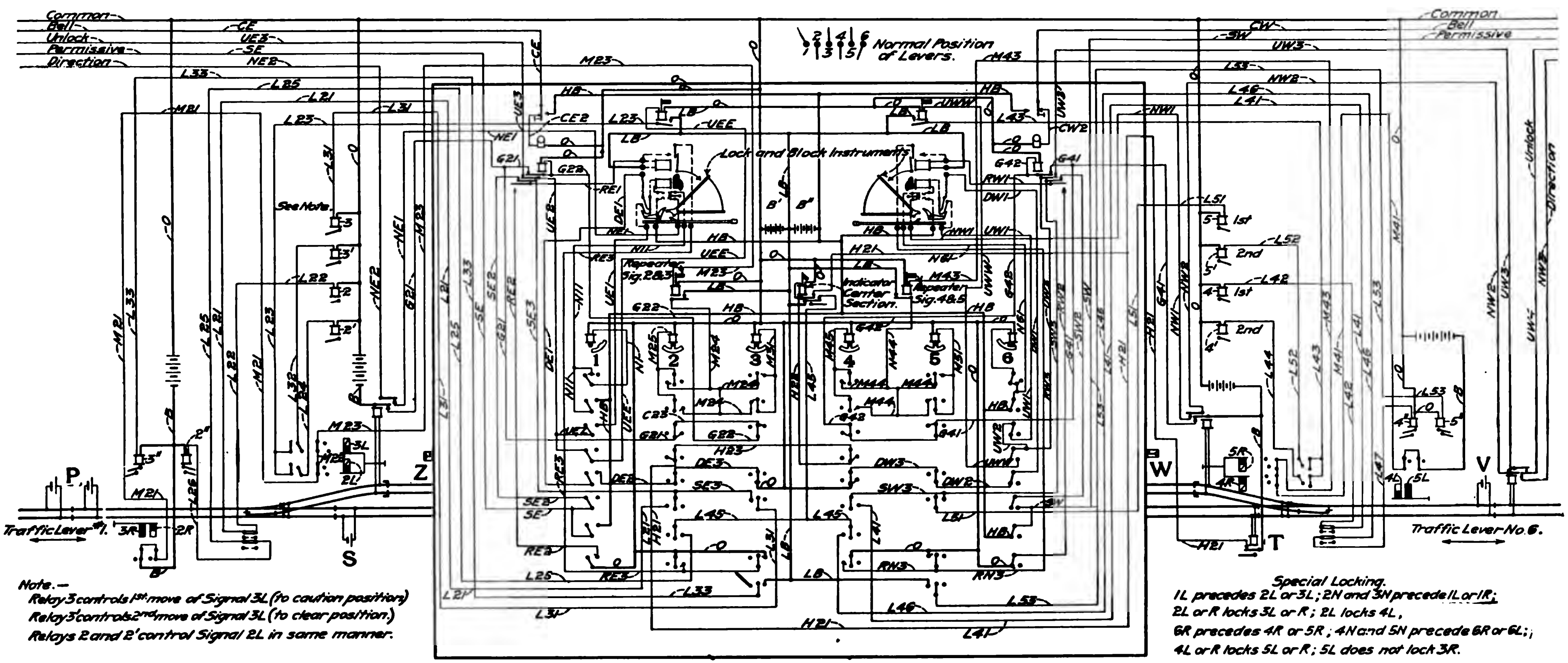


Fig. 272. Circuit Plan of Wiring and Instruments at Tower Y; Norfolk & Western Single Track Controlled Manual.

This plan joins at P with N in Fig. 271 on opposite page.

The controlling lever at Y now being to the right, a circuit is established from battery at Y, through contact on lever 1 to wire N-11 and thence back over same wires and through same relay contacts to middle contact of upper roller on lever 6 at X. As soon as X moves lever 6 to the right to mid-stroke position, battery flows from Y over the circuit already explained and through the electric lock on lever 6 at X to common. This unlocks lever 6 and permits X to complete the stroke to the right. Both controllers now being to the right, direction of traffic has been established from X to Y and, by means of electric locks, direction from Y to X prevented.

Referring now to the steps required for clearing the signal under lock-and-block control. Assume that direction of traffic is established from Y toward X, and it is desired to clear signal 2-L at Y in order to permit a train to proceed toward X. Signals 2-L and 3-L are both controlled by the lock-and-block instrument indicator at Y. This indicator can only be cleared by an unlock from station X. To give the unlock to Y the operator at X plunges the lock and block instrument at X and establishes the preliminary circuit from battery through the instrument to wire D-W-1, thence through contact on lever 6 closed when the proper direction of traffic is established, wire D-W-2, contact on lever 5, wire D-W-3, contact on lever 4 to common. This insures that levers 4 and 5 at X are normal, that signals 4-R and 5-R are at stop and that the proper direction of traffic is set up. When these conditions are fulfilled the unlock circuit proper is completed, sending battery from X to clear indicator at Y as follows: From battery at X through instrument to wire U-W-1, contact on lever 6, wire U-W-3, front contact on relay, wire U-W-3, front contact on track relay N-P, wire U-W-4 to wire U-E-3 at Y, front contact on relay, wire U-E-2, contact on lever 1, wire U-E-E, block instrument indicator to common.

When the block instrument indicator at Y has been cleared by the unlock received from X, either signal 2-L or signal 3-L may be cleared. Assume that signal 2-L is to be cleared; the lever 2 is moved to the left. Current then flows from battery at X, through contact on lever 6, to wire S-W, which is wire S-E at Y, through contact on lever 1 at Y, wire S-E-2, contact on repeater relay controlled by wire G-22, wire S-E-3, contact on lever 2 (now closed), wire L-21, contact in switch box, wire L-22, relay 2 to common. This energizes relay 2 and causes signal 2-L to go to the second or caution position. The signal in moving to the second position, closes the contact which completes a circuit from battery at Y, through block instrument indicator contact, wire L-23, contact on signal wire L-24, through relay 2', to common. This energizes relay 2' and allows the signal to move to the clear position. Signals 2-L and 3-L are interlocked by the mechanical locking in the machine so that only one of them can be cleared at a time.

Assume that signal 2-L has been cleared and the train has passed S. Track relay at 2-L is de-energized and opens the circuit from battery, through wire G-21, stick relay controlled by wire G-22, to common. The train now passes Signal 2-L, de-energizing the track relay at that point and also the stick relay. When the stick relay is de-energized it breaks the unlock circuit already described and also the signal control circuit. The indicator of the block instrument goes to danger, signal 2-L goes to stop, and the card of the block instrument shows "train in block." All apparatus is now stationary and locked. As the train proceeds and enters track section L-N at X, track relay at signal 4-R is de-energized, opening stick relay controlled by wire G-42. When the stick relay drops, battery flows through magnet on block instrument, wire R-W-1, back contact on stick relay, wire R-W-2, contact on lever 6 to common. This permits the card to drop about ¼ in., but still holds it on the second catch in "train in block" position.

Assume now that signal 4-L at X can be cleared to allow the train to proceed. When signal 4-L is cleared, the circuit for the release magnet in the block instrument at X is transferred from the back contact of the stick relay, controlled by wire G-42, to the stick contact on the block instrument. The circuit is then as follows: From battery through release magnet to stick contact wire R-N-3, contact on lever 4 to common. This holds the card in "train in block" position. In order to release the magnet and restore the instrument to normal with card showing "free," track section L-N must be free, energizing track relay at 4-R and the stick relay which it controls through wire G-42. This breaks the back contact on the stick relay to which wire R-W-2 is connected. It is also necessary to return lever 4 to the normal position, thus breaking the contact of wire R-W-3 and restoring signal 4-L to stop before the release magnet is entirely de-energized and the card allowed to drop. If the train is to take the siding, signal 5-L is cleared and lever 5 must also be restored normal with track section L-N "free" before the lock-and-block instrument is released.

The block K-L at X is track circuited and controls the indicator for the center section. When this indicator is clear either signal 4-L or signal 2-R can be cleared, but only one can be cleared at a time on account of the machine locking. When the train enters the block K-L under either signal cleared, the signal goes to stop automatically and cannot again be cleared until the lever is first returned to the normal position. This is accomplished by cutting the control for the lever locks on 2 and 4 through the indicator for the center section and the signal repeaters.

To permit of giving permissive signals some additional apparatus is required. It is essential in giving a permissive signal that the direction of traffic is locked so that it cannot be reversed until the signals are again restored to their normal position. Assume that the direction of traffic is established from Y toward X for a movement under signals 2-L or 3-L in the permissive position at block station Y. The opposing signals are 4-R and 5-R at X, and these must be at stop and so held as long as signals 2-L or 3-L at Y are in the clear or caution position. As the regular lock and block unlock wire between X and Y is cut through relays in the continuous track circuit another line wire, uncontrolled by track circuits, is required for the permissive function. The use of this wire, SW-SE, for carrying current from X to move signal 2-L to the second or caution position has already been explained. As long as a preceding train is in the block between X and Y the indicator of the lock and block instrument at Y is de-energized and hence signal 2-L cannot move to the third or clear position as already explained. As soon as all trains have cleared the block an unlock may be given from X to Y and the indicator at Y energized. This would automatically allow signal L to move from the caution position to the clear position.

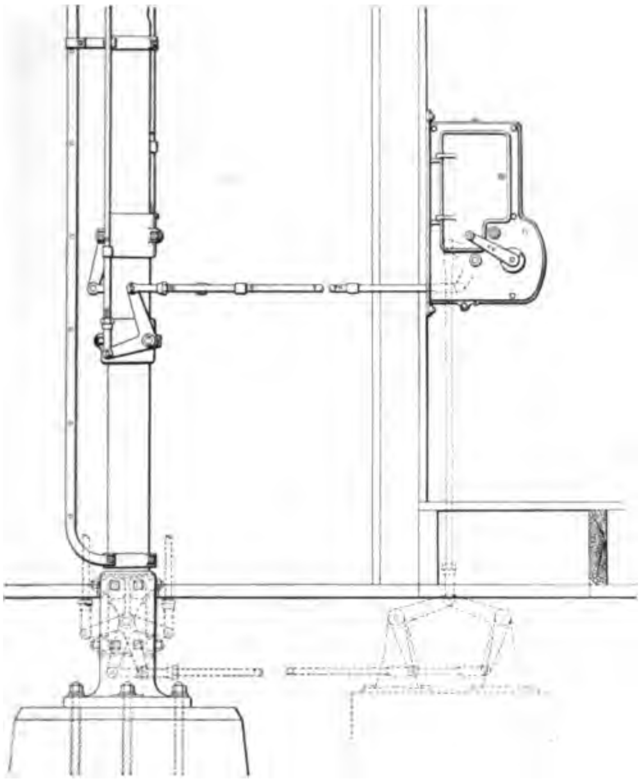


Fig. 273. Pipe Lead-out Connection from Block Instrument to Signal; General Railway Signal Company.

Fig. 275. Double Block Instrument for Single Track.

Fig. 276. Section Through Block Instrument.

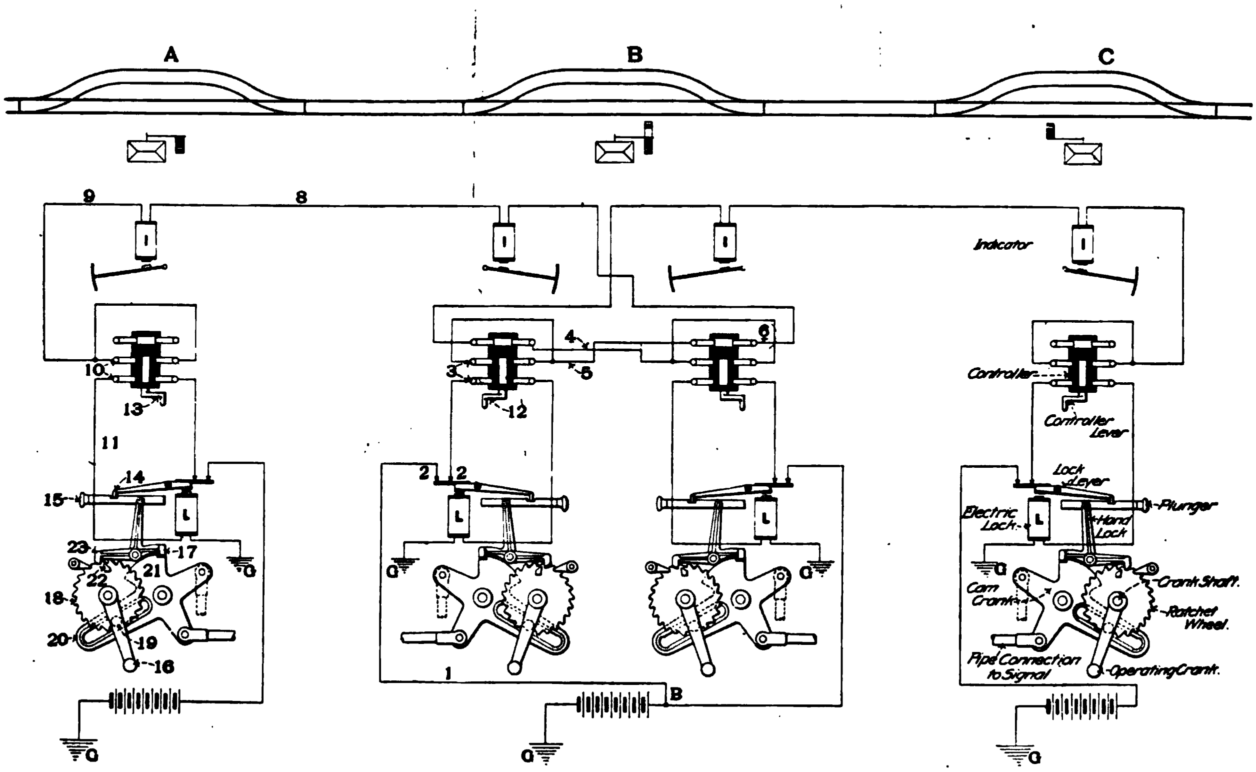


Fig. 277. Diagram of Circuits and Instruments for Typical Installation of Controlled Manual System for Single Track.

In Fig. 277 A, B and C represent block stations on a single-track road, with train movement to be made from A in the direction of C. In order to display "proceed" signal at A, it is first necessary for operator at A to request release or unlock from operator at B. If the block is unoccupied, the opposing signal at B in the stop position and other conditions favorable, operator at B closes circuit controller on his instrument by means of lever 12 connected thereto. This action must be simultaneous with the action of the operator at A, who closes similar controller on instrument at that point through lever 13. This joint action closes the unlocking circuit, causing current to flow from battery at B through wire 1, back contacts on electric locks 2-2, contact 3, wire 5, safety contact 6, wire 8, indicator 1 at A, wire 9, contacts 10, wire 11, coils of electric lock L at A, to ground or common. Indicator coils at A and B and lock coil at A are then energized, indicators showing unlocking circuit closed. Lock coil at A now attracts armature, releasing lock 14 and permitting the withdrawal by the signalman of plunger 15, which being connected to lock lever 17, releases cam crank 21 and permits the clearing of signal. The mechanical operation is effected by operator turning crank 16 a half revolution. This crank is directly connected to the shaft on which ratchet wheel 18 is mounted, the latter having a stud, 19, engaging slot 20 in cam crank 21. Thus the rotary movement of the mechanism is converted into linear movement at the pipe connection to clear the signal. The machine is connected as in Fig. 273.

After train has entered the block, the signalman completes the revolution of crank 16, thus placing signal in stop position and completing the movement. To prevent crank 16 from being turned except in the proper direction, ratchet wheel 18 is engaged by a pawl, thus ensuring proper operation of the crank. On this ratchet wheel a stud or boss, 22, is fixed in such a manner that when the crank, 16, is restored almost to normal position it engages arm 23 of lock lever 17, forcing same home and preventing further operation until another release or unlock is received.

Fig. 278 shows the system as illustrated in Fig. 277, with the addition of semi-automatic or slotted signals. The signals remain clear until the entire train has passed them, the signals returning to stop automatically immediately after the rear end has cleared. Power operated distant signals may be provided and operated in conjunction with the block instrument, as shown in Fig. 279. These signals indicate caution at all times, except when the block signal is clear, switches set for the main track and section between the distant and block signals is unoccupied.

Continuous track circuit without distant signals is shown in Fig. 280. In Figs. 281 and 282 a complete development of the system is illustrated; the arrangement showing block, home, distant and train order signals, continuous track circuit, indicators and electric locks at switches all under the control of operator at adjacent block station. No movement may be made from sidings to foul the main track without the permission and co-operation of the block operator at the adjacent station and the operator at the far end of the block, the same co-operation being required as for a main track movement.

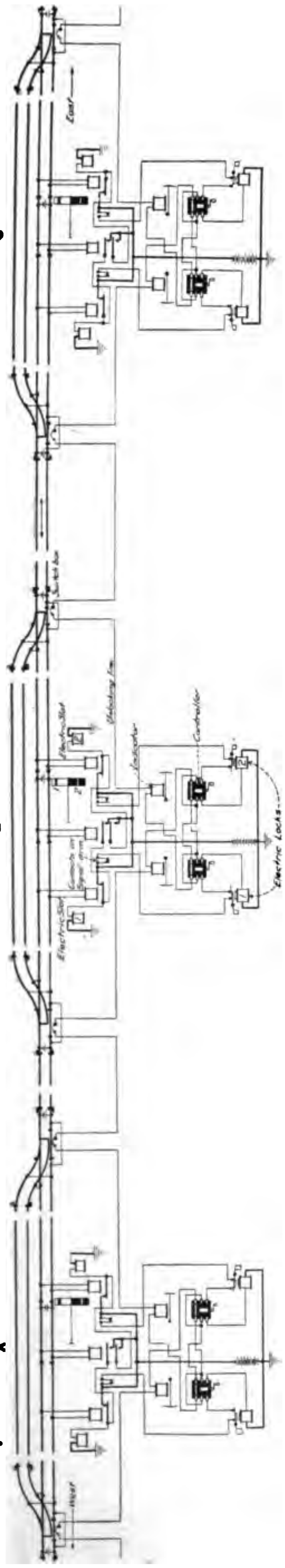


Fig. 278. Typical Circuits for Single Track; Non-continuous Track Circuits; Semi-automatic Signals.

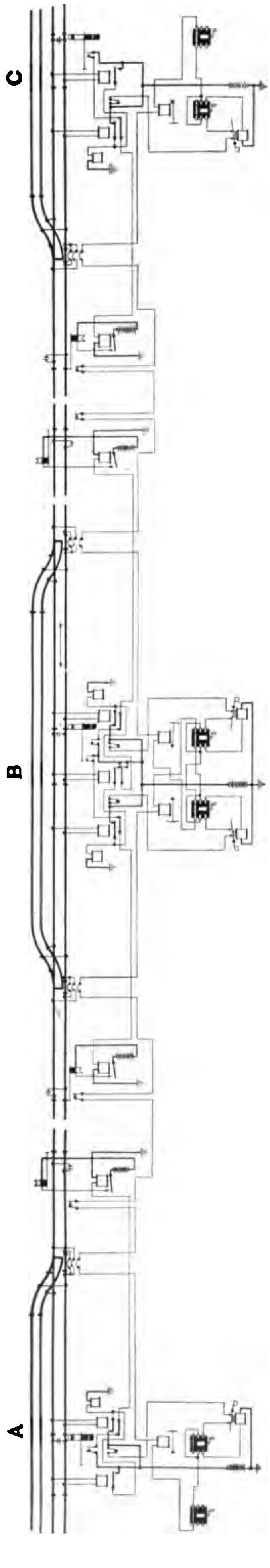


Fig. 279. Typical Circuit for Single Track. Similar to Fig. 278, with Addition of Power-operated Distant Signals and Contacts in Switch Boxes for control of Track Circuits.

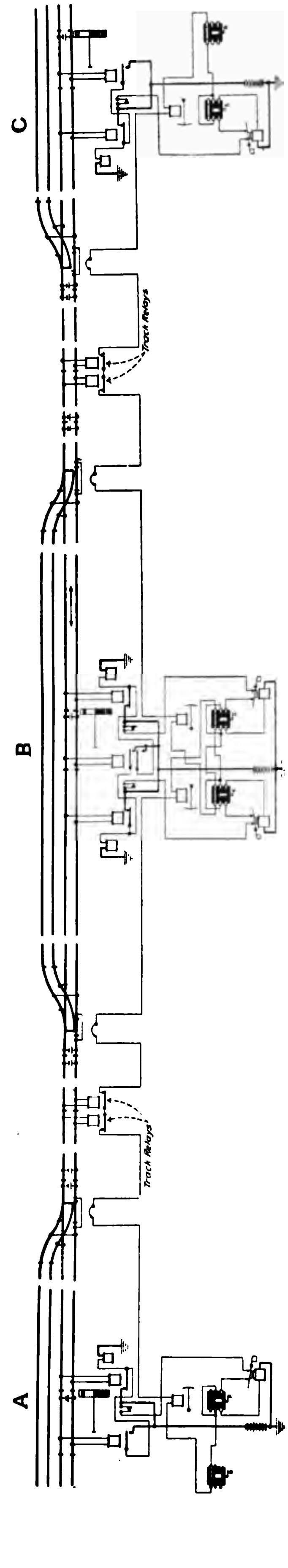
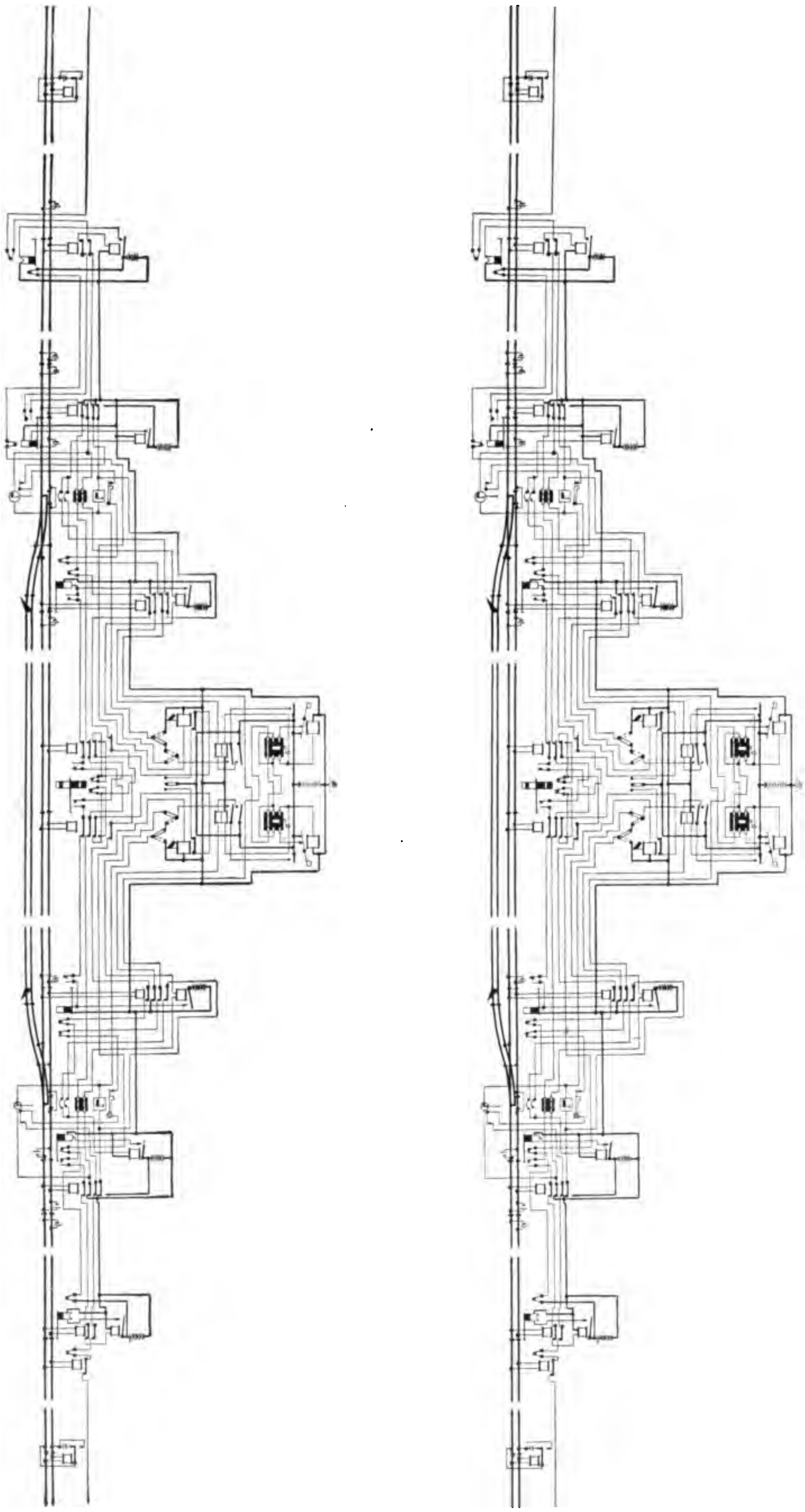


Fig. 280. Typical Circuit for Single Track; Continuous Track Circuits.



Figs. 281-282. Arrangement of Circuits for Complete Development of System, showing Power-operated Home and Distant Block Signals, Train-order Signals, Indicator and Electric Locks at Switches and Continuous Track Circuits.

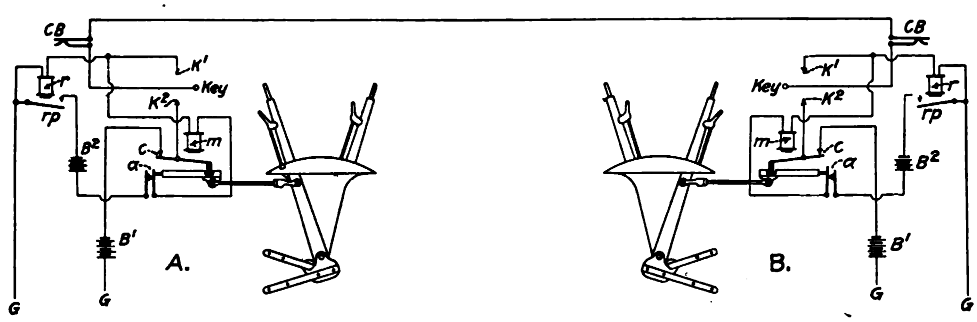
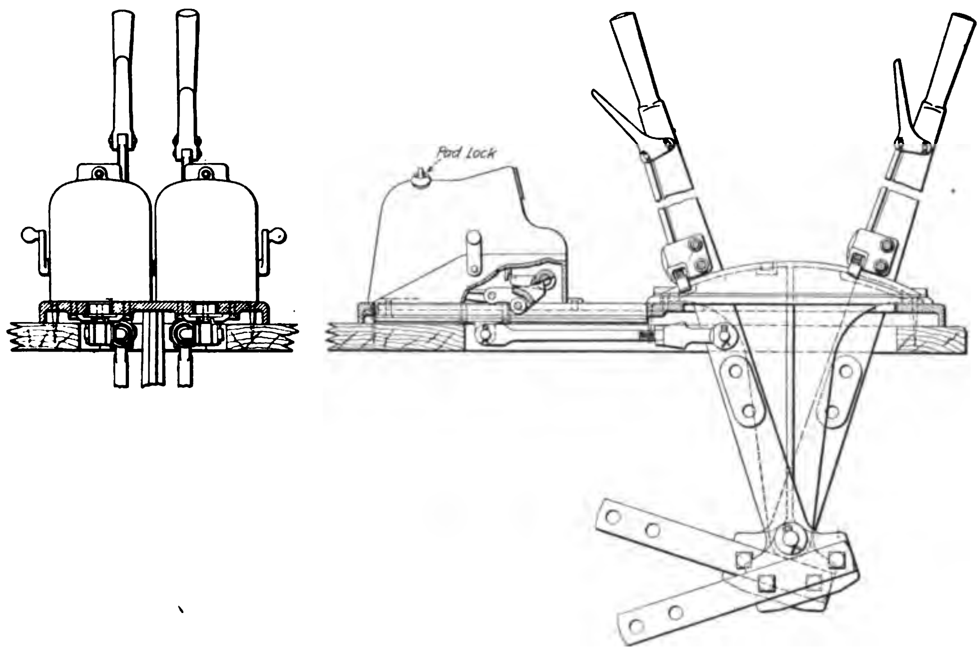


Fig. 283. Circuits for Controlled Manual Block Signals on Single Track. Chicago & Eastern Illinois.



Figs. 284-285. Electric Locks, Applied to Table Lever Machine for use in Controlled Manual Block System. Chicago & Eastern Illinois.

On the Chicago & Eastern Illinois, manual block signals on single track are electrically locked by a specially devised apparatus, in which no track circuits are used. Fig. 283 is a diagram of the circuits. The apparatus at the two stations A and B is identical and a grounded circuit is used. Assume that A wishes to clear his signal for the movement of a train toward B. Having notified B by telegraph, telephone or bell code, A presses his key against front point k^1. If B is ready to clear A's signal, B throws his key to contact with its back point k^2. This closes the circuit from the ground, G, through B's battery B^1 and key, to the line and through A's key, and "stick" relay *r*, to the ground. This causes the stick relay to lift its armature and thereby close the circuit of battery B^2 through A's latch magnet m, withdrawing the latch and releasing A's lever. As soon as B presses his key, and actuates A's stick relay, he may at once release it, as magnet m and the circuit through it and r are now energized by battery B^2. A's lever now being free to move he pulls it, and the instant he does so the circuit through the latch magnet is broken at *a*, permitting the latch to drop again and rest on top of the bar. The opening of the circuit at *a* de-energizes *r* so that it is also opened at *rp;* so that the signal cannot be cleared a second time without another restoration of the current from B, with, of course, the concurrent action of A. The action is the same in the reverse direction. The operator, after getting an "unlock," may hold it indefinitely and may delay clearing his signal until time to do it in accordance with the rule to clear it in view of an approaching train; but as long as he is unlocked he cannot give the other operator a release, for his battery is cut off at *c*. A circuit-breaker, CB, is placed on the signal post and worked by the semaphore arm. If the arm is not in the stop position the circuit is broken and neither station can clear the other. The apparatus for each block is separate and distinct, having no connection with adjoining blocks. There are two levers at each station, a northbound and a southbound, with the corresponding semaphores, and separate locking mechanisms and circuit connections as illustrated.

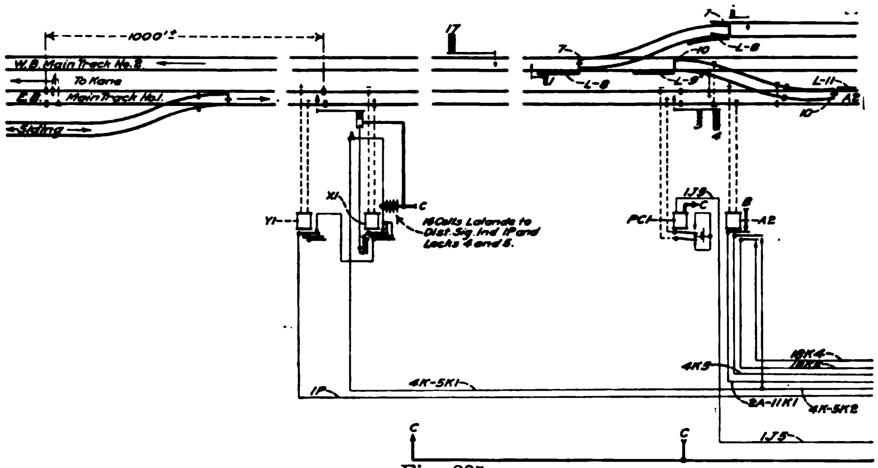


Fig. 285.

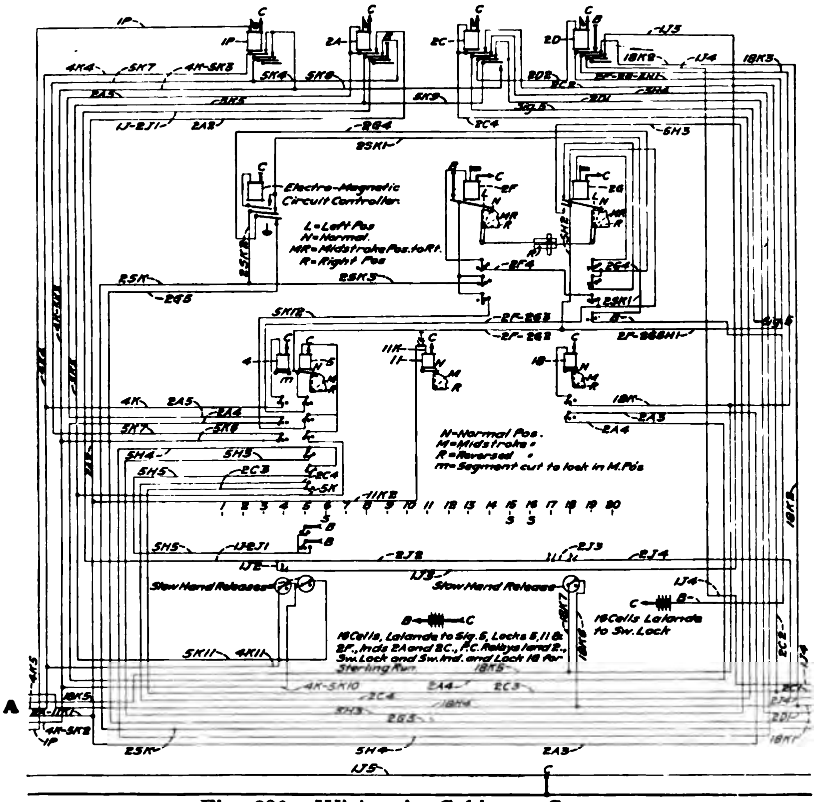


Fig. 286. Wiring in Cabin at Cameron.

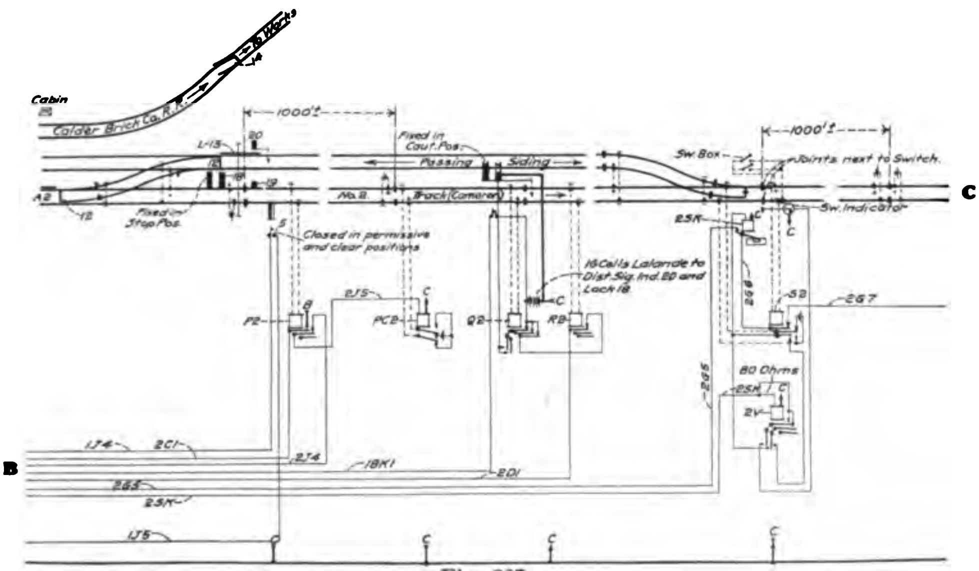


Fig. 287.

Figs. 285-287. Circuits for Single Track Controlled Manual Block Signals. Pennsylvania Railroad.

Note.—Figs. 285-290 are parts of a single diagram. The connections from one part to another are indicated by letters; **A** in Fig. 285 joins **A** in Fig. 286, **B** in Fig. 286 joins **B** in 287, and so on.

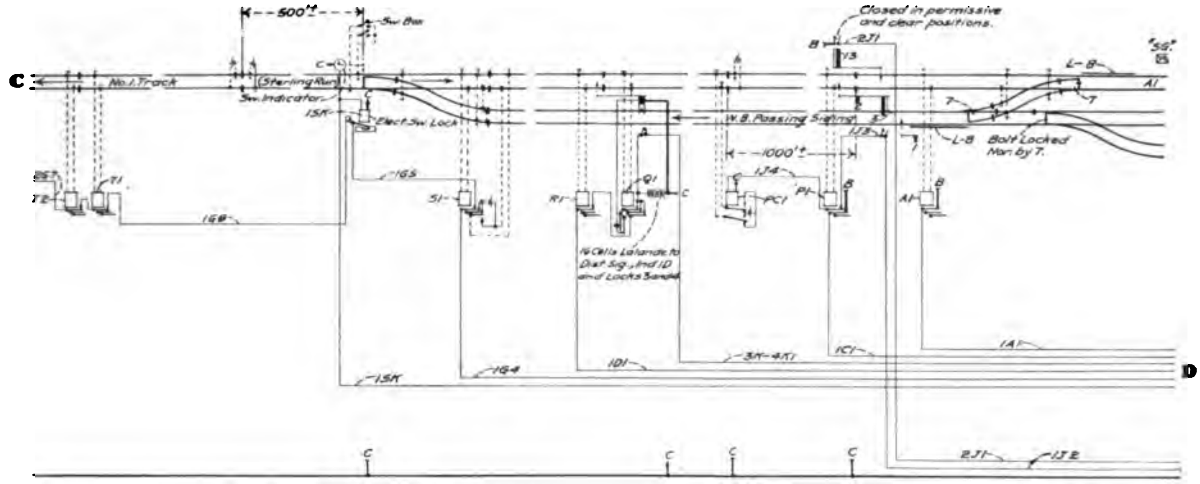


Fig. 288.

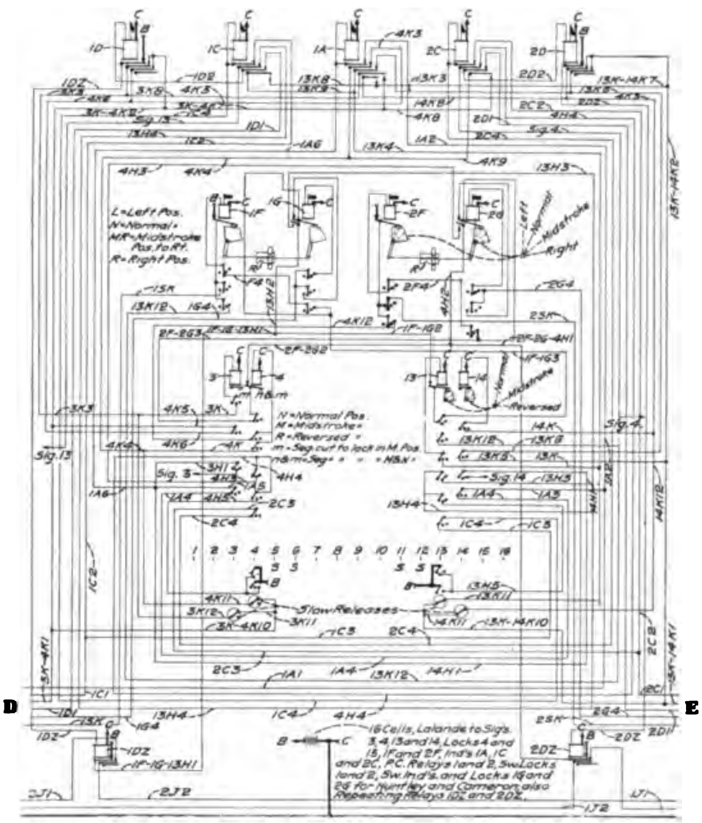


Fig. 289. Wiring in Cabin at Sterling Run.

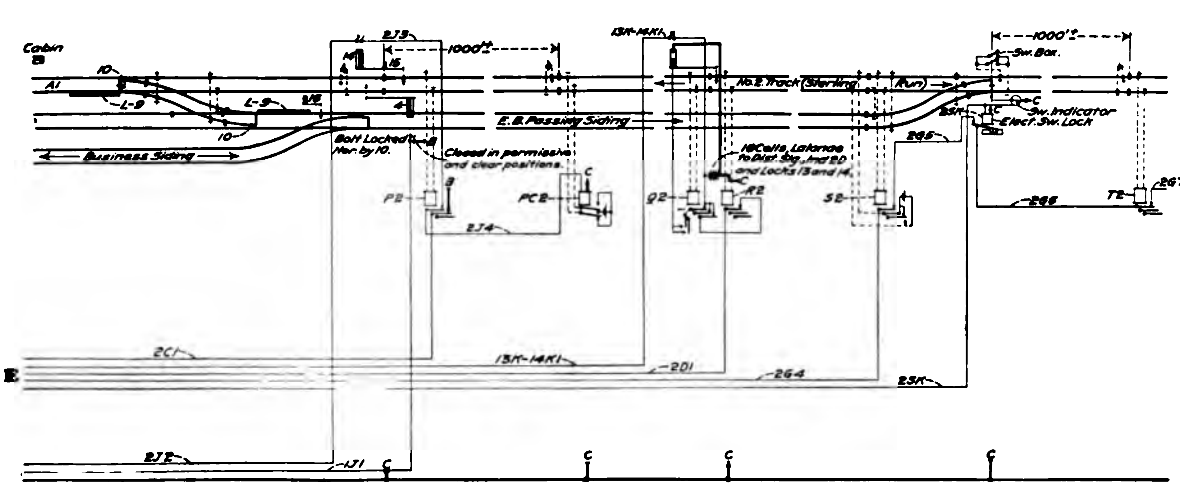


Fig. 290.

Figs. 288-290. Circuits for Single Track Controlled Manual Block Signals. Pennsylvania Railroad.

Figs. 285-290 show the circuits used for a Single Track Controlled Manual Block System on the Pennsylvania Railroad between Cameron, Pa., and Sterling Run. This system provides protection against butting collisions, but is permissive for following movements. Electric approach locking is provided at both plants. The circuits for this approach locking are similar to those shown in Figs. 2001-2008.

At each station there is a block instrument for each block (1-G. 2-G); there is also a signal controlling instrument (1-F 2-F). These instruments are similar to those shown in Figs. 267-268. There is also at each station in addition to the ordinary indicators an indicator (1-C, 2-C) which shows whether or not the track is occupied for a distance of 1,000 ft. beyond the advance signal; and an indicator (1-D, 2-D) which shows whether or not the track is occupied between the advance signal and a point several hundred feet beyond the outlying switch. Switch indicators are placed at such switches in addition to the switch locks to indicate to a train on the siding whether or not it has permission to proceed on to the main line.

To move a train from Cameron (Figs. 285-286-287) to Sterling Run (Figs. 288-289-290) the procedure is as follows: Operator at Cameron asks operator at Sterling Run for an unlock. This is given by moving the handle of controller 1-G (see Figs. 288-290) at Sterling Run to the left. This closes a circuit from B, front contact on relay 1DZ at Sterling Run through wires 1F-1G-13H1, 1F-1G2, contact on electric lock 13, controller on same lock, wire 1F-1G3, upper contact on controller 1-G, middle circuit breaker of same controller, wire 1G4, contact of relay S1, wire 1G5, contact on switch lock, 1SK, wire 1G6, contacts on relays T1, T2, wire 2G7, contact of relay S2 at Cameron, contact of switch lock 2SK, wire 2G5, back contact of electro magnetic circuit controller at Cameron, wire 2G4, circuit controller on 2G, coils of 2G, to common. This energizes 2G and releases its handle for a movement to the right. The operator at Cameron moves handle of 2G to the right. This releases handle 2F through the tappet locking at K and closes a circuit from B at indicator 2D, through a point of 2D, wire 2F-2G-5H1, wire 2F-2G2, contact on lock 5, circuit controller on lock 5, wire 2F-2G3, circuit breaker on 2G, wire 2F4, circuit controller on 2F, coils 2F to common. This energizes 2F and releases its handle. The operator moves the handle of 2F to the right. This releases the lever of signal 5 and the signal can be cleared.

The signal is put to the stop position behind the train by the slot. The slot circuit is controlled by indicators 2C and 2D when 2G is energized. When 2G is de-energized, as when a train is anywhere between stations, it is controlled by 2C only. The arrangement of contacts on lever 5, where slot 5 gets current from B, is such that the slot can be kept energized with a train beyond the control of indicator 2C if the lever is not pulled beyond the middle position (see wire 5H5 and two lower contacts on lever 5). This indication is given for permissive signaling.

Provision is also made for letting a train out of a siding at a switch in the block after any and all trains admitted to the block have passed the switch. It is not necessary to wait for the block to be actually cleared by a train moving in the facing direction. A train can be let out of a siding after the passage of a train in the trailing direction, but not while such train is moving from the block station to the siding switch (see switch lock circuits SK).

Names of Parts of Electric Train Staff Instrument; Figs. 294-296.

1 *Back and Cover*
2 *Indicator*
4 *Locking Bar for Disk Indicator*
6 *Drum Locking Lever*
7 *Armature Raising Lever*
8 *Locking Drum Gear*
9 *Receiving Drum Gear*
10 *Operating Lever Cam*
12 *Eccentric*
15 *Terminal Post*
18 *Contact Spring*
22 *Connecting Bar*
23 *Magnet*
24 *Terminal Post*
26 *Single Stroke Bell*
29 *Contact Spring of Bell Key*
37 *Shield Plate and Knob*
38 *Glass for Indicator Opening*
39 *Slot in* **6**
40 *Locking Drum*
41 *Vertical Slot*
42 *Staff Indicator Needle*
43 *Current Indicator Needle*
44 *Indicating Disk*
45 *Preliminary Handle*
46 *Push Button*
47 *Spiral Slot*
48 *Opening for Withdrawing Staff*

Names of Parts of Pusher Attachment for Electric Train Staff; Figs. 301-303.

1 *Cover*
2 *Bracket for Contact Springs*
3 *Contact Spring*
4 *Terminal Post*
5 *Contact Lever Bracket*
6 *Pivot Pin for* **7**
7 *Contact Lever*
8 *Contact Spring for Lever* **7**
9 *Pin Connecting* **7** *with* **11**
10 *Hook for Spring* **12**
11 *Eccentric Rod*
12 *Releasing Spring for* **7**
13 *Bearing for Locking Dog* **14**
14 *Locking Dog*
15 *Right-hand Half of Socket for Pusher Staff*
16 *Left-hand Half of Socket for Pusher Staff*
17 *Pivot for Locking Levers*
18 *Separator*
19 *Long Locking Lever*
20 *Short Locking Lever*
21 *Stud for Holding Cover in Place*

Names of Parts of Intermediate Siding Staff Instrument; Figs. 305-307.

B *Locking Drum and Frame*
1 *Back and Cover*
2 *Indicator*
3 *Indicator Disk*
4 *Connecting Bar for Disk Indicator*
5 *Drum Locking Lever*
6 *Drum Locking and Armature Raising Lever*
7 *Operating Lever Cam*
8 *Eccentric*
9 *Eccentric Rod*
10 *Bracket for Supporting* **11** *and* **12**
11 *Armature Lever*
12 *Lever for Pole Changer Contact Springs*
13 *Bracket for Contact Springs*
14 *Contact Spring for* **11**
15 *Contact Spring for* **12**
16 *Contact Spring for* **13**
17 *Terminal Post*
18 *Sleeve and Machine Screw for Bracket* **13**
19 *Magnet*
20 *Terminal Post*
21 *Bracket for Bell Terminals*
22-23 *Single Stroke Bells*
24 *Bell Magnet*
25 *Terminal Board*
26 *Insulating Bushing*
27 *Push Button Circuit Controller*
28 *Contact Spring*
29 *Short Contact Terminal Post for* **27**
30 *Long Contact Terminal Post for* **27**
31 *Front Plate*
32 *Glass for Indicator Opening*
33 *Hasp*
34 *Base*

THE ELECTRIC TRAIN STAFF SYSTEM.

Figs. 291-296 show the electric train staff instrument made by the Union Switch & Signal Company, for use on single track lines. One instrument is installed at each end of the block; that is, in a continuous installation, two at each block station. Fig. 297 shows the wiring diagram for two staff block stations. To move a train from X to Y the manipulation of the instruments is as follows: The operator at X presses bell key, A, the number of times prescribed in the bell code, which rings the bell at Y, through the circuit 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17. The operator at Y first acknowledges receipt on his bell key by ringing the bell, L, at X (through the circuit 19, 20, 21, 8, 7, 6, 5, 4, 22, 23, 24, 25, 17, 16, 15, 14, 13, 26), and then holds it closed, thereby deflecting the "current indicating needle," 43, Fig. 296, at X to the right. This informs X that Y has furnished X current and he proceeds to remove the staff by turning the preliminary handle, 45, Fig. 296, to the right as far as it will go, which raises the armature up to the magnet, K, transferring the current from bell L, to the coil K88, through the circuit 19, 20, 21, 8, 7, 6, 5, 4, 22, 23,

Fig. 291.

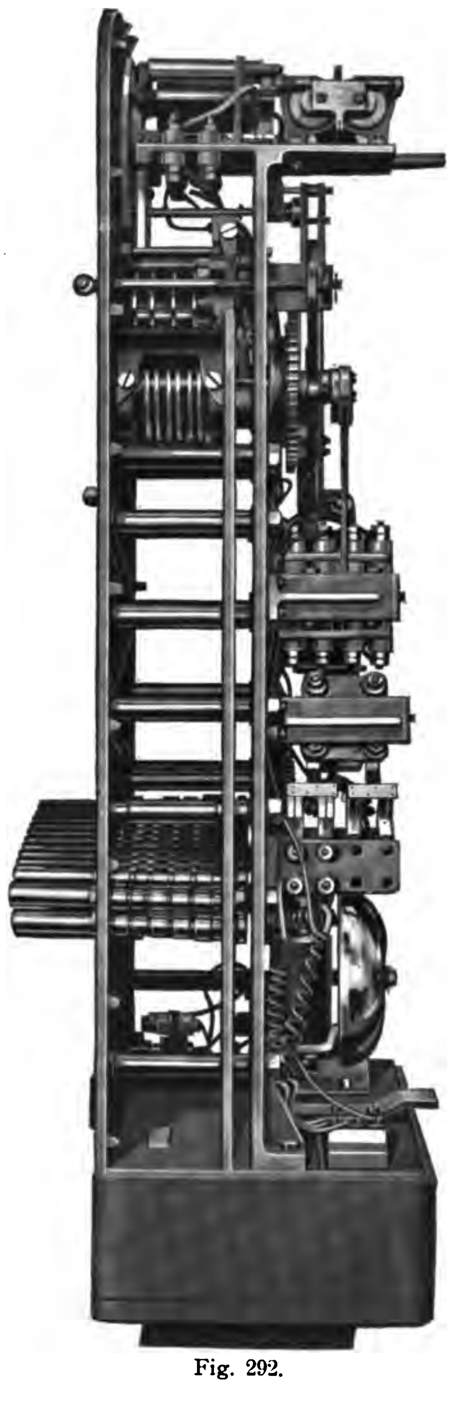


Fig. 292.

Electric Train Staff Instrument. The Union Switch & Signal Company.

Fig. 293. Electric Train Staff Instrument, Mounted, Showing Arrangement of Lightning Arresters.

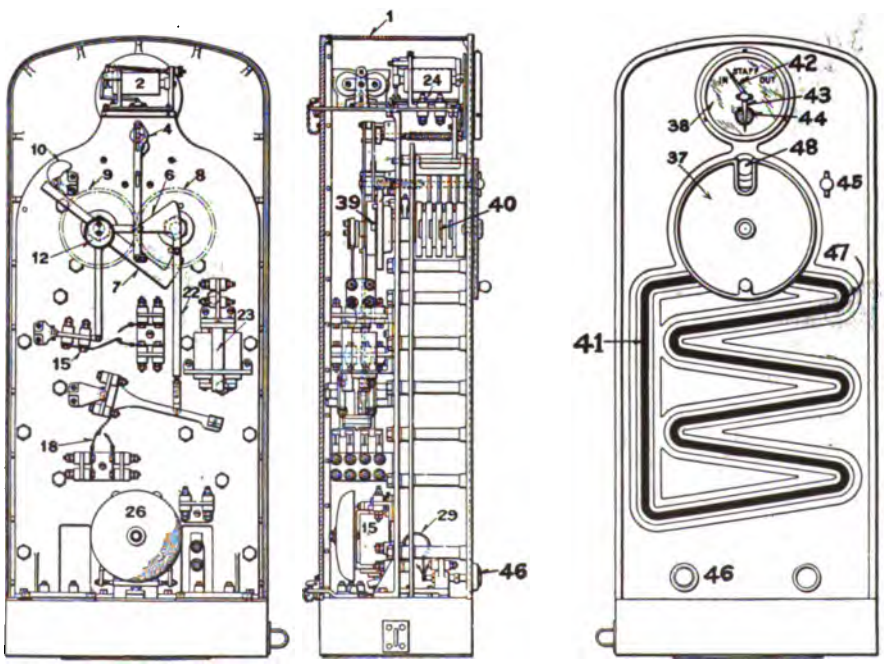
27, 28, 25, 17, 16, 15, 14, 13, 26, and at the same time closing the circuit on coil K360, through the circuit, 1, 2, 29, 30, 28, 25, after which the preliminary spindle handle is permitted automatically to return to its normal position. This unlocks the revolving drum, 8, Fig. 294, and indicates the fact by displaying a white instead of a red disk in the indicator, 44, Fig. 296. The operator now moves the end staff up the vertical slot into engagement with the drum (the outer guard having first been turned to the right position) revolving the latter through half a turn using the staff as a handle, and finally withdraws the staff through the opening at 48, Fig. 296. In making the half turn the drum has reversed the polarity of the operating current thereby throwing the instruments at X and Y out of synchronism* with each other and moving the "staff indicating needle," 42, Fig. 296, from "staff in" to "staff out." Immediately on withdrawing the staff the operator at X once more presses his bell key, A, which indicates to the operator at Y, by moving his needle from "staff in" to "staff out" that the operation is completed.

The staff is now delivered to the train. The magnet, K, has two separate coils, one energized by the local and one by the line battery. The construction of this magnet is such that when the currents in both coils flow in the same direction the lines of force pass around the cores and connecting straps, thus forming no point of attraction for the armature. When the current is reversed in one coil the lines oppose each other and the armature, being brought to the point of attraction, is held there. The polarity of the local current going through the magnet, K360, Fig. 297, is never changed. The polarity of the current flowing through K88, Fig. 297, is changed every time the staff is put in or taken out of either instrument. This puts the instruments either in or out of synchronism. With the staff out, the circuits are as follows: From the positive side of the battery at Y, through 19, 20, 21, bell key, A, closed, 8, 7, 6, 5, 17, 25, 24, 23, 22, 4, 16, 15, 14, 13, 26, to the negative side of the battery at Y. If an attempt should be made to release a staff by turning the preliminary handle, the operating current would be transferred from the bell, L, to coil, K88, through 19, 20, 21, bell key, A, closed, 8, 7, 6, 5, 17, 25, 28, 27, 23, 22, 4, 16, 15, 14, 13, 26, to the negative side of the battery at Y. By comparing this circuit with the one described for releasing the staff it will be seen that in the former the currents flowing through coils K360 and K88 oppose each other, and in the latter they do not, which prevents the releasing of a staff.

On arrival of the train at Y the staff is delivered to the operator, who places it in the opening, 48, Fig. 296, of his instrument, having first turned the outer guard, 37, Fig. 296, to place, moves the staff into engagement with the drum, 9, Fig. 294, revolves it through one-half turn, using the staff as a handle, and allows it to roll down the spiral. He then presses his bell key the prescribed number of ties, thus notifying X that the train is out of the section, which operation also moves the "staff indicating needle" at X from "staff out" to "staff in." The operator at X presses his bell key in acknowledgment, and by so doing moves the "staff indicating needle" at Y from "staff out" to "staff in." The machines are now synchronized and another staff can be obtained from either in the manner outlined above. The staff being put in the instrument at Y the circuits are as follows: From the positive side of the battery at Y, through 19, 20, 21, bell key, A, closed at Y, through 8, 14, 15, 16, 4, 22, 23, 24, 25, 17, 5, 6, 7, 13, 26, to the negative side of the battery at Y. Should a release be required, the preliminary spindle at X would be turned and the current transferred from the bell to magnet K88 through the following circuit; from the posi-

*The term "synchronism" as here applied does not denote the same condition as when used in connection with alternating current apparatus, but simply means that the polarity of the current furnished by one instrument is such that it co-operates with that in the other instrument to permit the release of a staff.

Numbers Refer to List of Names of Parts on Page 38.



Figs. 294-296. Electric Train Staff Instrument.

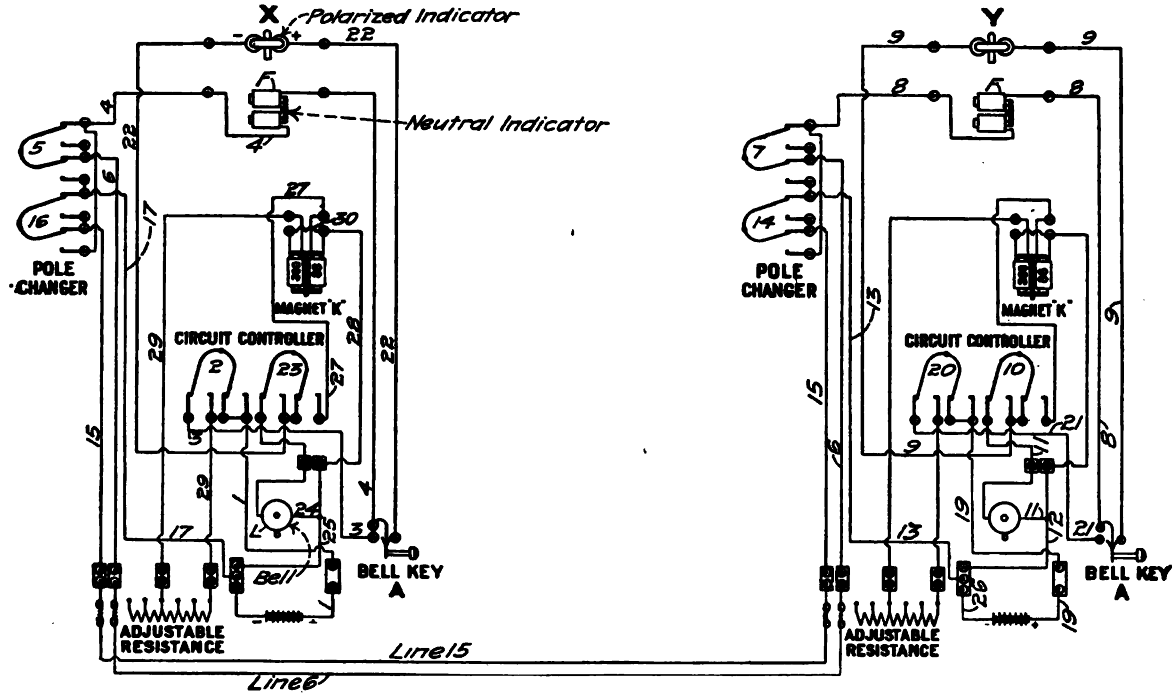
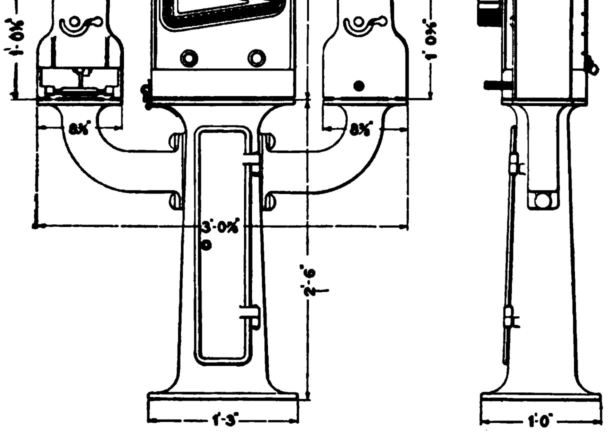


Fig. 297. Circuit for Electric Train Staff.

tive side of the battery at Y through 19, 20, 21, bell key closed at Y, through 8, 14, 15, 16, 4, 22, 23, 27, 28, 25, 17, 5, 6, 7, 13, 26, to the negative side of the battery at Y. It will be seen that the current flowing through the magnets K360, K88, are again opposing each other, consequently a staff can be released.

Cases occur where it is desirable to allow one or more trains to follow one another into the block at short intervals before the first train has passed out. This is known as the permissive system and consists of an attachment (Figs. 298, 299 and 308), to the absolute machine at each end of the section with one permissive staff. An absolute staff is always locked in a permissive attachment when it does not contain the permissive staff.

Now, assuming that the permissive staff (A, Fig. 317) is at X, to operate this feature, an absolute staff is withdrawn from the instrument at X in the usual manner and used as a key to unlock the attachment containing the permissive staff, which is then taken out. The opening of the base and the removal of the permissive staff locks the absolute staff in the permissive attachment there to remain until the permissive staff is replaced. The permissive staff consists of a steel rod and 11 removable rings, any one of which authorizes a train to pass through the section to Y. If less than 12 trains are to follow each other, the last one takes all the remaining rings and the steel rod. When all the rings and the rod are received at Y, the operator reassembles them into the complete permissive staff which he then places in the base of his permissive attachment and locks it there, releasing the absolute staff already in the lock of this instrument. He then removes the absolute staff which he restores to the absolute instrument in the regular manner. The machines are now synchronized and a movement can be made with an absolute staff in either direction, and from Y to X with the permissive. If it is again found necessary to move several trains from X to Y under the permissive system, the permissive staff must be taken out by Y, as before described, and forwarded to X as a whole by the first train moving in that direction. When the train receives the entire permissive staff it confers the same rights as does an absolute staff.



Figs. 298-299. Electric Train Staff with Permissive and Pusher Attachments.

Where signals are used to indicate to an approaching train whether or not it will receive a staff (Fig. 318), an instrument known as the staff lever lock (Figs. 310-312) is attached to each lever operating such signals. To clear a signal the staff after being withdrawn is first used to unlock the lever lock. The signal is then cleared and the staff removed from the lock and delivered to the train. To insure the signals being restored to stop position behind the train, the act of unlocking the signal lever opens the staff circuit and no communication can be made between the two staff stations until the signal is at stop and the lever locked in that position. This does not indicate, however, that the operator will have the staff ready for delivery by hand, or in the mechanical deliverer. To cover this point an electric slot is attached to the signal governing train movements into the staff section. This slot is controlled by the staff lever lock and the mechanical deliverer (Figs. 318-325), so that before the signal can be cleared the staff must be released, used to unlock the signal lever and put in the staff deliverer, which closes the circuit on the electric slot. The signal can then be cleared. With this arrangement, therefore, a clear signal cannot be given until the staff is actually in the deliverer. When the train picks up the staff the circuit in the slot is opened automatically, putting the signal to danger. The signal cannot again be cleared until the operation described above is repeated. Fig. 309 shows three views of a circuit controller attachment which is used in connection with electric or electro-pneumatic signals, instead of the mechanical lock (Figs. 310-313), just described. It is arranged to control the staff and signal circuits. The circuits controlling the signal for a movement into the staff section cannot be closed until the staff has been used to release the handle of the controller. The staff can then be taken out and given to the train, but the staff circuits will remain broken until the handle of the circuit controller is again locked in its normal position.

If in some sections there is a siding of sufficient length to hold a train, but traffic does not warrant placing a staff block station at that point, a special instrument (Figs. 304-307) is placed at the siding which enables it to be used for a meeting or passing point. The operation is as follows: A train arriving at the staff station X has not time to proceed to Y, but can proceed as far as the siding.

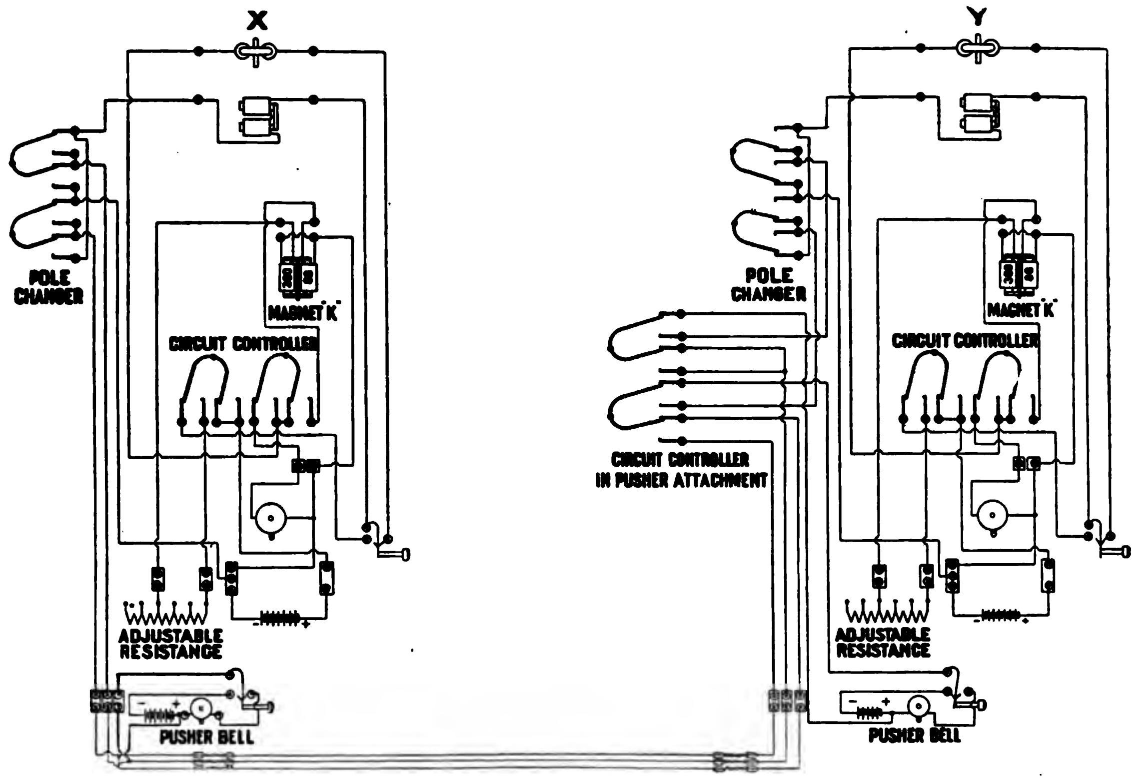


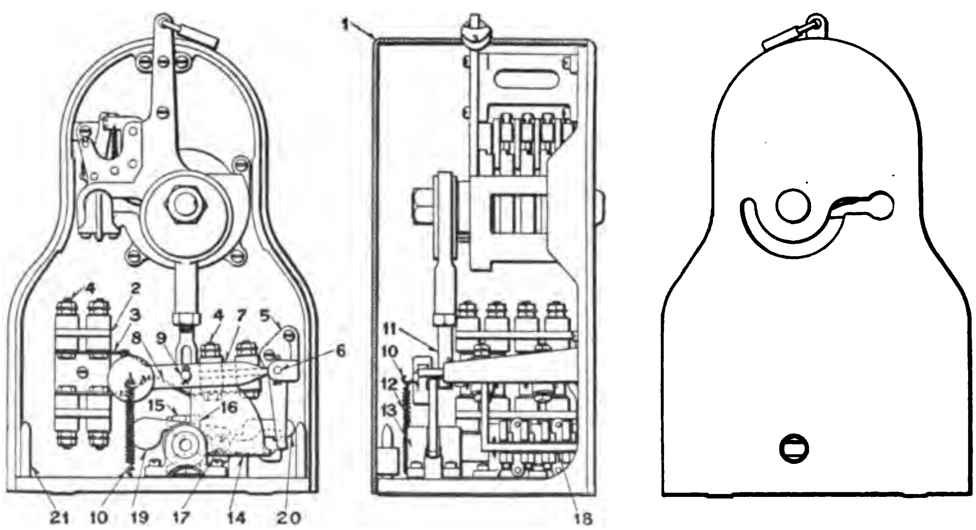
Fig. 300. Circuits for Pusher Attachment, Showing Connections when Pusher Staff is Out; Electric Train Staff System.

The operator at X gives the train the staff with instructions to proceed to the siding. Unlocking the switch with the staff, the train takes the siding, closes and locks the switch, places the staff in the siding instrument and turns the drum to the right. The staff is now locked in the instrument and the staff instruments at X and Y are synchronized and the fact indicated to both operators, so that trains may be sent through the section in either direction. When all trains having precedence over the one in the siding have passed through the section and the staffs have been replaced in the instruments, X and Y acting in conjunction, can release the staff at the siding, which on being removed changes the circuits so that no staff can be released at either X or Y. The train on the siding then closes the switch with the staff and proceeds to Y or back to X. A junction or diverging line may be situated between two points most suitable for staff stations. Such points can be controlled the same as a passing siding.

The staff is also used as a key to unlock siding switches which may occur between staff stations. The switch lock (Figs. 314-316) is so designed that the staff cannot be removed from the lock until the switch is set and locked for the main line, thus providing protection against misplaced switches.

Another adjunct to the staff system is known as the pusher engine attachment and staff. It is used on heavy grades where pusher engines are required and is intended to obviate the necessity of the pusher engine preceding through the entire staff section. It is also evident that, in such cases, all the staffs would in time be brought to the bottom of the grade. It consists of a separate device which may be attached to any absolute staff instrument (Figs. 298-303), and contains a staff of special design (Nos. 5-8, Fig. 317), which can only be released by a regular staff, though, unlike the permissive staff, it can be out of its receptacle at the same time as the regular staff. When so removed it opens the controlling cir-

Numbers Refer to List of Names of Parts on Page 38.



Figs. 301-303. Pusher Attachment for Electric Train Staff System.

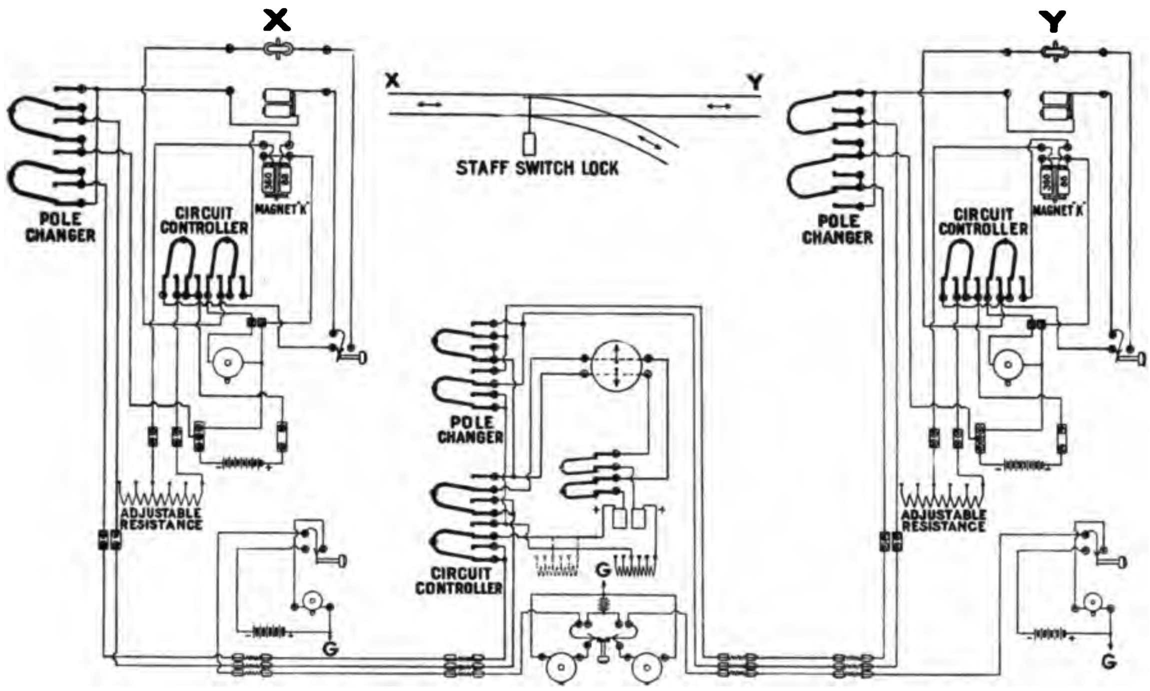


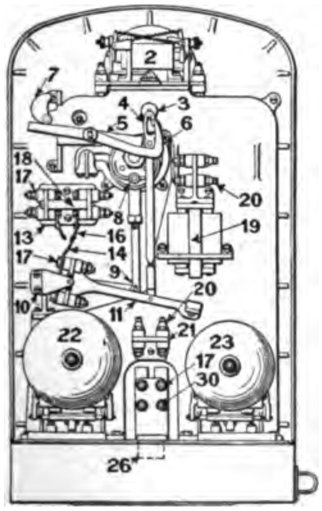
Fig. 304. Circuits for Intermediate Siding Staff Instrument; Electric Train Staff System.

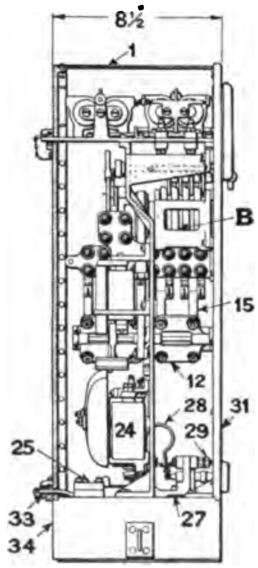
cuits of the system (Fig. 300), preventing any other movement being made until it has been returned and locked in the pusher attachment. The operation is as follows: A train with a pusher wishes to proceed from Y to X. X releases a staff at Y and Y uses this staff to release the pusher staff. Y then hands the regular staff to the train and the pusher staff to the pusher engine. The train passes through the section and delivers the regular staff at X. This is placed in the instrument there; the pusher engine retains the pusher staff and returns to Y. Until this latter staff is put into the pusher attachment at Y and locked, the staff circuits are not re-established and no other staff can be released.

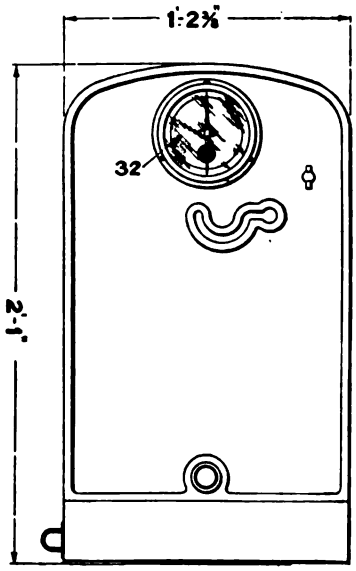
Absolute staffs can be furnished in two pieces, screwed together, when so desired, the object of this being to deliver one-half to the engineman and the other half to the conductor of the train, so that should a train break in two and part remain in the section, the forward portion on leaving the section would deliver only one-half of the staff which would not be sufficient to unlock the machine.

To avoid the possibility of the staff belonging to one pair of instruments in a continuous installation being used to unlock one of another pair at either end of the block, staffs are made in four different patterns (Nos. 1-4, Fig. 317), so that it would be necessary to carry one staff improperly through three entire blocks before reaching one where it would fit an instrument.

Letters and Numbers Refer to List of Names of Parts on Page 38.







Figs. 305-307. Intermediate Siding Staff Instrument; Electric Train Staff System.

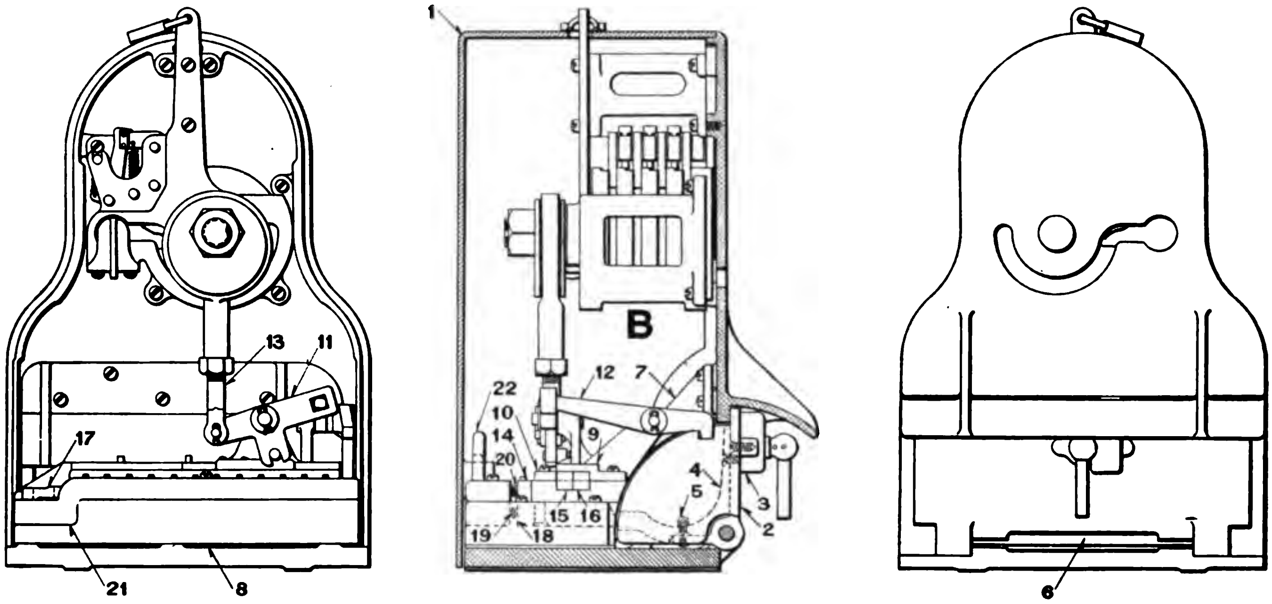


Fig. 308. Permissive Attachment for Electric Train Staff System.

Names of Parts of Permissive Attachment, Fig. 308.

B *Locking Drum*
1 *Cover*
2 *Drawer*
3 *Drawer Lock*
4 *Cradle*
5 *Guard Bar for Permissive Staff*
6 *Hinge Pin*
7 *Permissive Staff Shield*
8 *Bed Plate*
9 *Cover Plate*
10 *Cover Bar*
11 *Eccentric Lever*
12 *Lock Lever*
13 *Eccentric Rod*
14 *Lock Bar Operated by Permissive Staff*
15 *Lock Bar Operated by Eccentric*
16 *Lock Bar Operated by* **2**
17 *Crank for Operating* **16**
18 *Dog for Operating* **17**
19 *Spring for* **18**
20 *Spring for* **14**
21 *Socket for* **19** *and* **20**
22 *Stud for Cover*

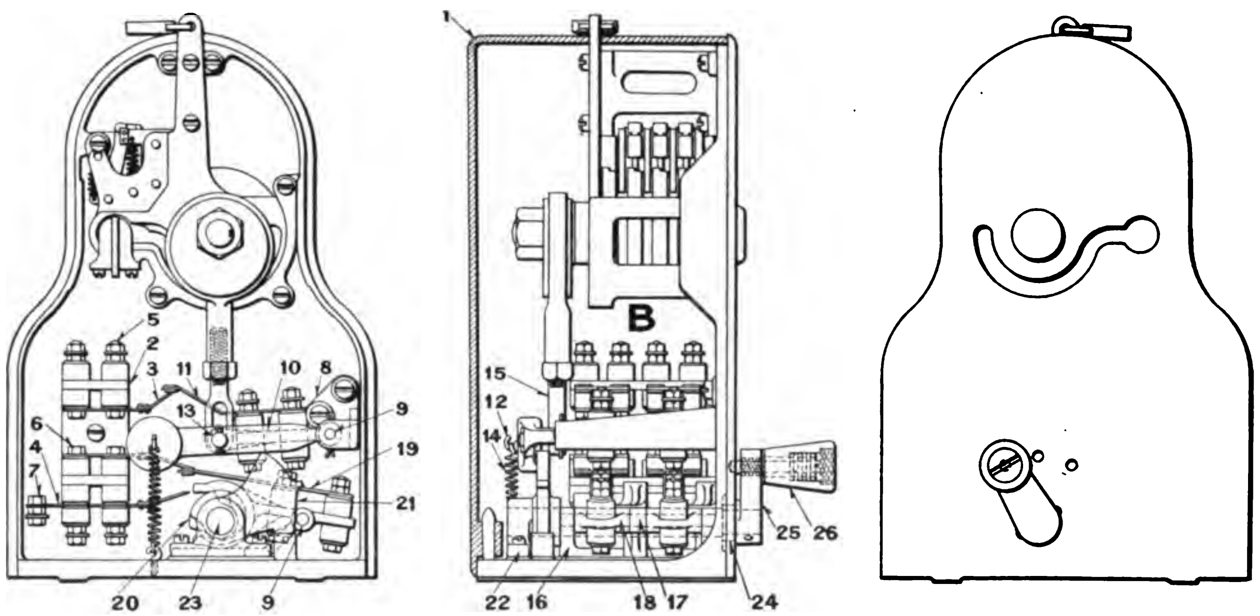
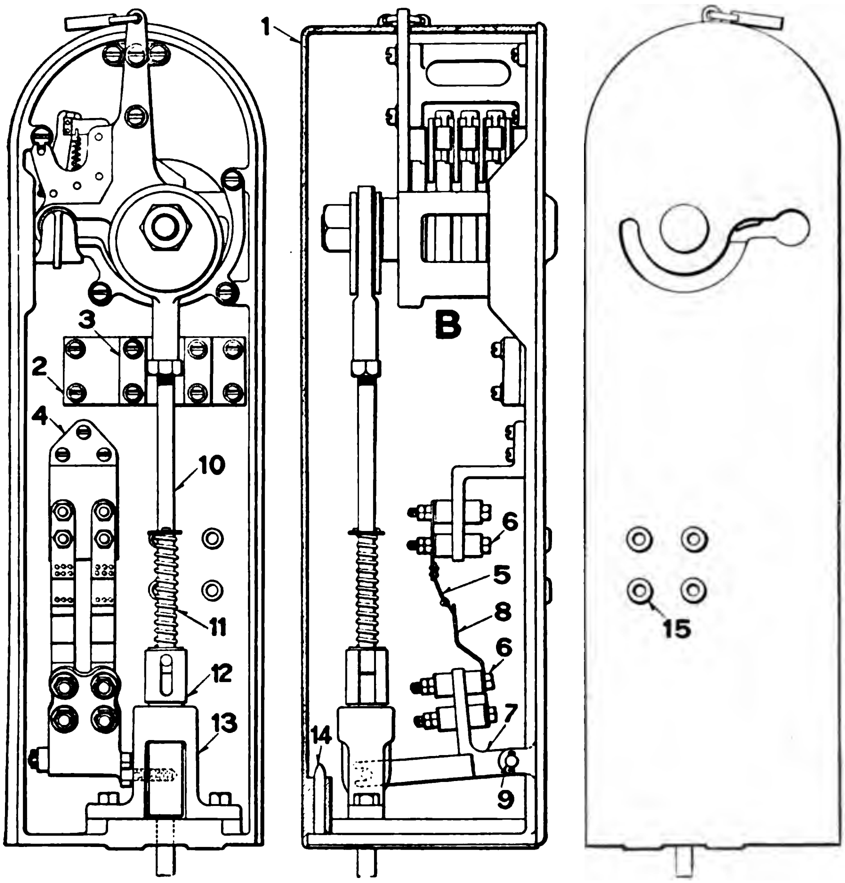


Fig. 309. Circuit Controller Attachment for Electric Train Staff System.

Names of Parts of Circuit Controller Attachment, Fig. 309.

B *Locking Drum and Frame*
1 *Cover*
2 *Contact Spring Bracket*
3 *Contact Spring for* **2**
4 *Contact Spring with Terminal Post*
5 *Terminal Post*
6 *Long Terminal Post for* **4**
7 *Short Terminal Post for* **4**
8 *Bracket for* **10**
9 *Pivot Pins*
10 *Contact Lever Operated by Eccentric*
11 *Contact Spring for* **10**
12 *Hook on* **10** *for* **14**
13 *Pin for* **10** *and* **15**
14 *Spring for Releasing Lever* **10**
15 *Eccentric Rod*
16 *Bracket for Contact Levers* **18**
17 *Separator*
18 *Contact Lever Operated by Cam*
19 *Contact Spring for* **18**
20 *Cam for Operating* **18**
21 *Locking Dog*
22 *Bearing for* **23**
23 *Shaft*
24 *Bushing for Shaft* **23**
25 *Arm for Shaft* **23**
26 *Handle*



Figs. 310-312. Staff Lever Lock for Electric Train Staff System.

Names of Parts of Staff Lever Lock; Figs. 310-312.

- **B** *Locking Drum and Frame*
- **1** *Cover*
- **2** *Terminal Board*
- **3** *Two-Way Terminal*
- **4** *Bracket for Contact Springs*
- **5** *Contact Spring for* **4**
- **6** *Terminal Post*
- **7** *Lever for Contact Springs*
- **8** *Contact Spring for* **7**
- **9** *Pin with Cotters*
- **10** *Eccentric Rod*
- **11** *Eccentric Rod Spring*
- **12** *Plunger*
- **13** *Plunger Guide*
- **14** *Stud for Holding Cover in Place*
- **15** *Insulating Bushing*

Names of Parts, Staff Switch Lock; Figs. 314-316.

- **1** *Case*
- **2** *Cover*
- **3** *Hinge Pin*
- **4** *Front Plate and Base*
- **5** *Locking Dog*
- **6** *Stud for Locking Dog*
- **7** *Tap Bolt, for Fastening Lock to Lever*
- **8** *Screw, Fastening* **4** *to* **1**
- **9** *Screw, Fastening* **4** *to* **1**

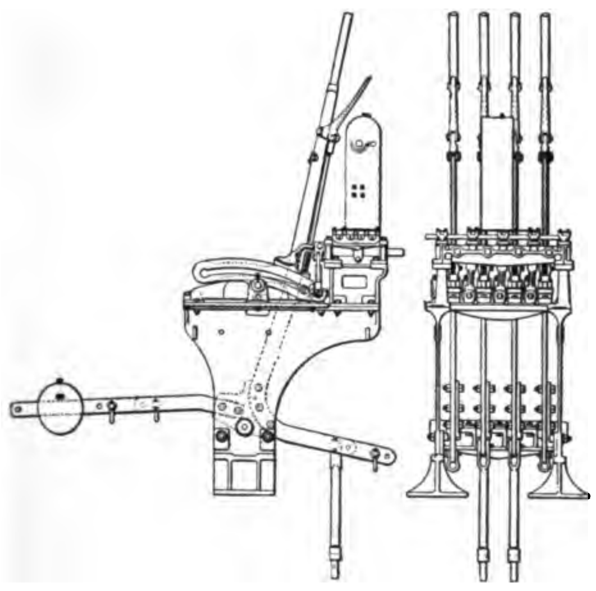
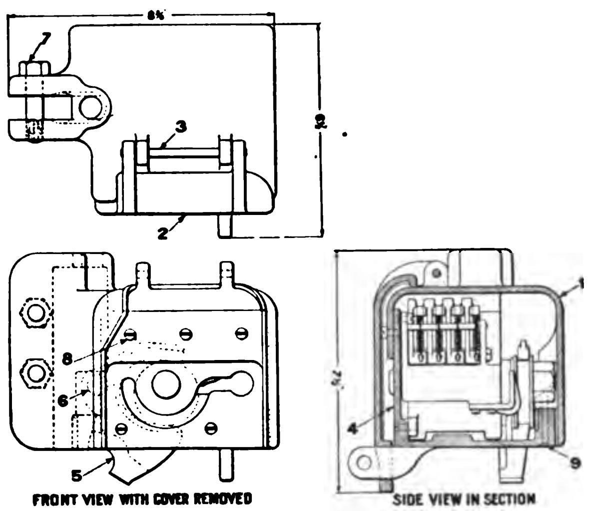


Fig. 313. Staff Lever Lock Applied to Saxby & Farmer Interlocking Machine.



Figs. 314-316. Staff Switch Lock; Electric Train Staff System.

Names of Parts of Standard, Pusher and Permissive Staffs; Fig. 317.

- **A** *Permissive Staff Complete with Disks and Knob*
- **1** *Absolute Staff, No.* 1
- **2** *Absolute Staff, No.* 2
- **3** *Absolute Staff, No.* 3
- **4** *Absolute Staff, No.* 4
- **5** *Pusher Staff, No.* 1
- **6** *Pusher Staff, No.* 2
- **7** *Pusher Staff, No.* 3
- **8** *Pusher Staff, No.* 4

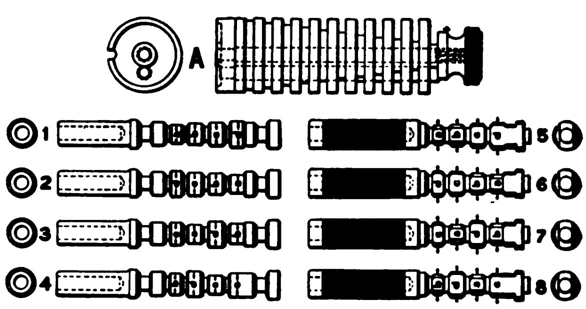


Fig. 317. Standard, Pusher and Permissive Staffs; Electric Train Staff System.

Fig. 318. High Speed Staff Catcher, Electric Train Staff System. Cincinnati, New Orleans & Texas Pacific.

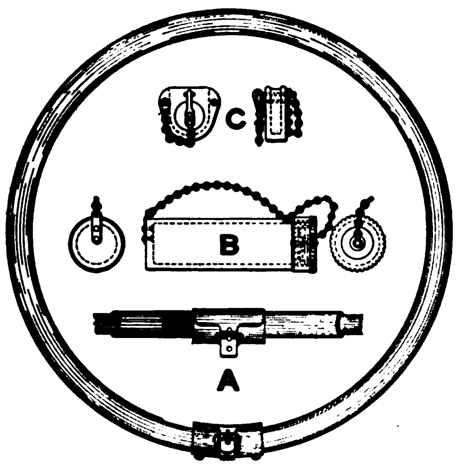
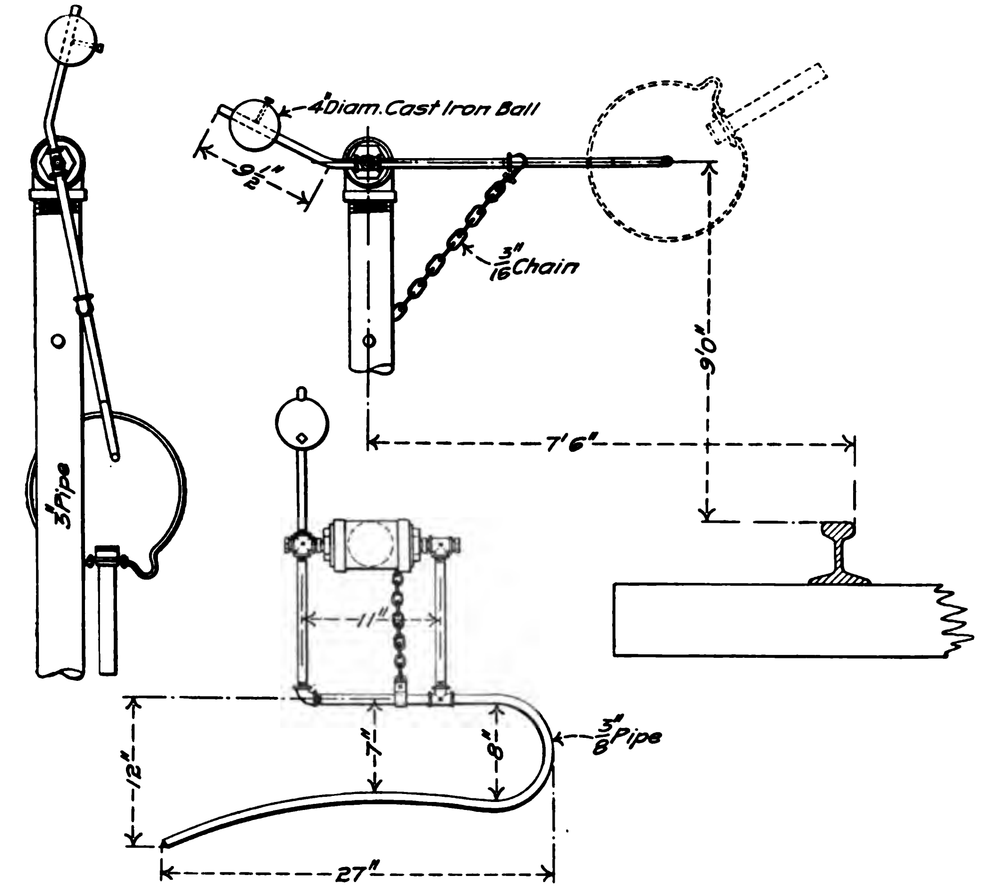


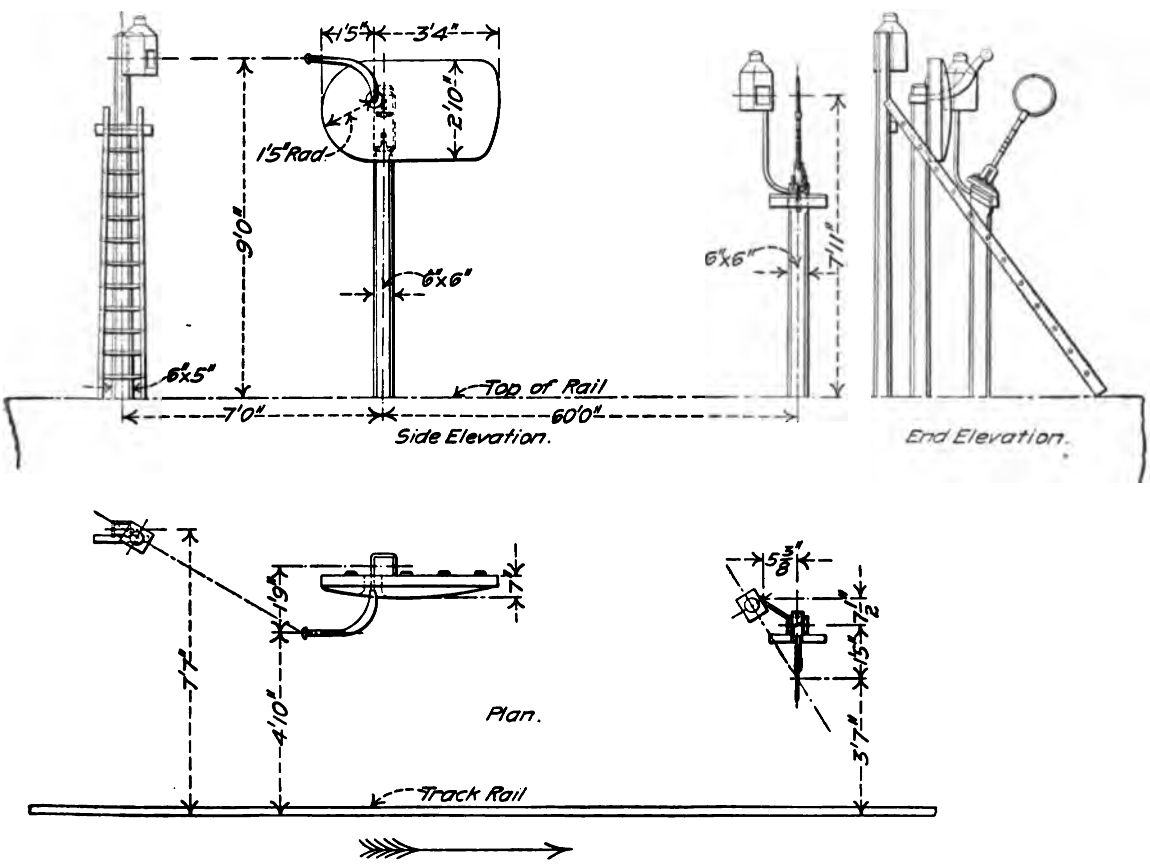
Fig. 319. Staff Catching Apparatus; Electric Train Staff System.

Names of Parts of Train Staff Catching Apparatus; Fig. 319.

A *Ring Staff Pouch*
B *Pouch for Permissive Staff*
C *Pouch for Permissive Staff Disk*



Figs. 320-322. Staff Catcher. Union Pacific.



Figs. 323-325. Staff Catcher and Deliverer. Great Western Railway of England.

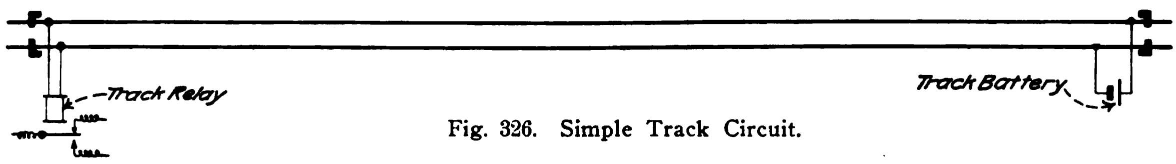


Fig. 326. Simple Track Circuit.

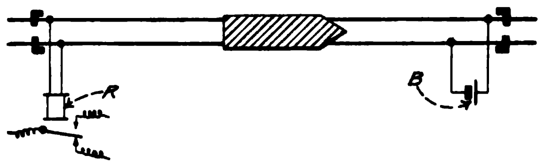


Fig. 327. Track Circuit Occupied by Train Moving from Relay to Battery.

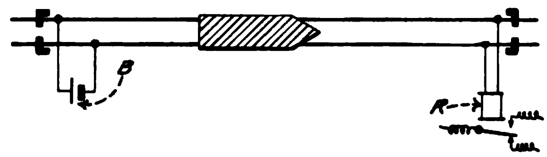


Fig. 328. Track Circuit Occupied by Train Moving from Battery to Relay.

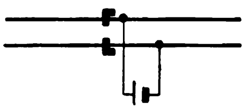


Fig. 329.

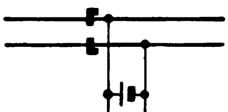


Fig. 330.

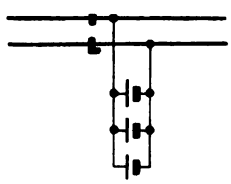


Fig. 331.

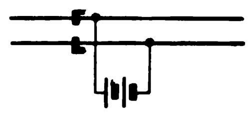


Fig. 332.

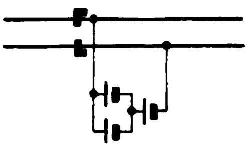


Fig. 333.

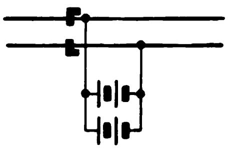


Fig. 334.

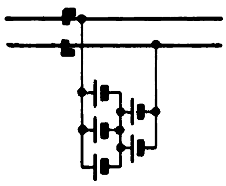


Fig. 335.

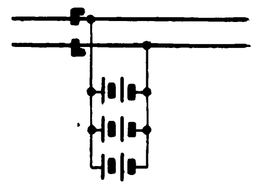


Fig. 336.

Figs. 329-336. Various Arrangements of Cells of Battery Used on Track Circuits.

THE TRACK CIRCUIT

The track circuit, which is the vital feature of modern block signaling and has made the present high development of the art possible, is a simple electrical device. Its essential feature is a section of track insulated at each end from the adjoining sections of the track. Each rail in the section is connected to the ones adjoining by bond wires, for the purpose of making a continuous conductor from one end of the section to the other. The contacts made by ordinary rail splices are not good electrically owing to wear, rust and the loosening of bolts. Two bond wires are usually used at each joint, so that should one break, the circuit will remain continuous through the other. These bond wires are secured to the rail by means of "channel pins" or other suitable devices. On electrically operated roads where tracks are bonded for the return propulsion current with heavy copper bonds, no additional bond wires are necessary. At one end of the insulated track section a battery is placed, the positive terminal being connected to one rail and the negative terminal to the other. At the other end of the section a relay is connected to the rails in a similar manner. Fig. 326 shows a typical track circuit. Current flows from the positive side of the battery through the lower rail, the relay and the upper rail back to battery. This keeps the relay energized.

The track relay is a development of the instrument of the same name used in the telegraph. It consists of an electro-magnet of the horse-shoe type, provided with an armature. The armature is attracted to the magnet when the latter is energized and is drawn away by gravity or by a spring when the magnet is de-energized. The armature carries one or more fingers for making or breaking electric circuits through points or stops. (See Figs. 2553-2612.)

The presence of a pair of wheels or train in the section will short-circuit the battery, shunting the current out from the relay and causing its armature to drop, because the resistance through the wheels and axle of an ordinary car or engine is infinitesimal compared with that of a relay of 3½ ohms or more. Consequently the relay is deprived by the wheels and axles of current necessary to maintain its attractive power for the armature. The minimum resistance usual in track relays is 3½ ohms. Fig. 327 shows the effect of a train on the track circuit; the train is assumed to be passing from the relay end to the battery end of the section. The effect would be the same should the train move in the opposite direction with respect to the battery and relay (Fig. 328), except that the relay would not release quite so quickly. This is in part due to the self-induction of the circuit through the relay coils, the rails and the axles of the train. It is due more, however, to small leakage from the adjoining section and the effects of stray earth currents which are always present to a greater or less degree. A broken rail would also open the circuit and de-energize the relay.

Circuits for the control of various signaling devices are broken through the contact points of the track relay. Such apparatus cannot be operated directly by the track circuit because to furnish them with sufficient current a battery of large electro-motive force would be needed. On account of the low insulation resistance of the ties and ballast it is unwise to use a battery of more than two volts potential. With any higher voltage the leakage from rail to rail, especially in wet weather, becomes equivalent to the presence of a train in the section. For the same reason track circuits cannot be made of unlimited length. The resistance of the rails also has to be considered in determining the length of a track circuit.

Almost any kind of closed circuit primary battery can be used to supply current to a track circuit, but in practice gravity or storage is ordinarily used. Gravity battery is used to a greater extent than any other type of primary battery on account of its suitability to closed circuit work. It has a high internal resistance compared with its electro-motive force, and therefore will not exhaust so rapidly as other types. Potash or soda batteries might be used by inserting resistance, in the same manner as with storage battery, except that they are found not to be so economical in practice. When gravity battery is used not more than two cells are usually placed in series. Figs. 329-336 show various arrangements of this type in general use for track circuits. The following table shows the maximum current flowing under certain given conditions. In this table 1.079 volts is taken as the maximum initial E. M. F. of a gravity cell, and two ohms as the minimum internal resistance of same.

	Maximum current (in mil-amperes)		
	Track shunted.	Through 9-ohm relay.	Through 3½-ohm relay.
Fig. 329	539.5	98.09	196.18
" 330	1079.0	107.9	239.78
" 331	1618.5	111.62	258.96
" 332	539.5	166.0	287.73
" 333	719.33	179.83	332.0
" 334	1079.0	196.18	392.36
" 335	1294.8	202.31	417.68
" 336	1618.5	208.84	446.48

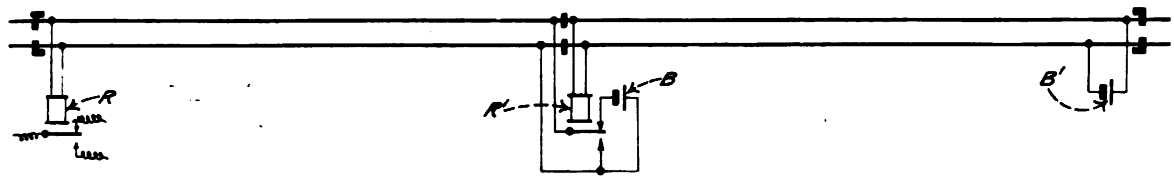


Fig. 337. Cut Section Track Circuit.

A single block section divided in the middle because of difficulty in operating long track circuits.

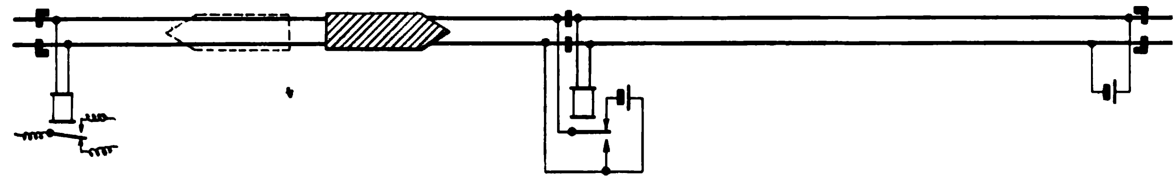


Fig. 338. Cut Section Track Circuit—Train in Relayed Half.

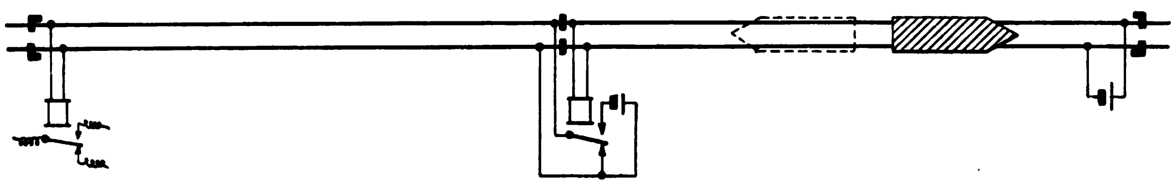


Fig. 339. Cut Section Track Circuit—Train in Relaying Half.

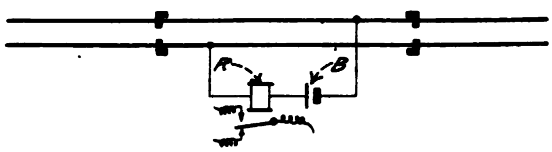


Fig. 340. Normally Open Track Circuit.

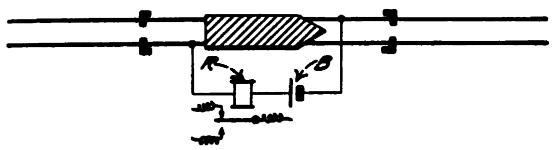


Fig. 340a. Normally Open Track Circuit Occupied by Train.

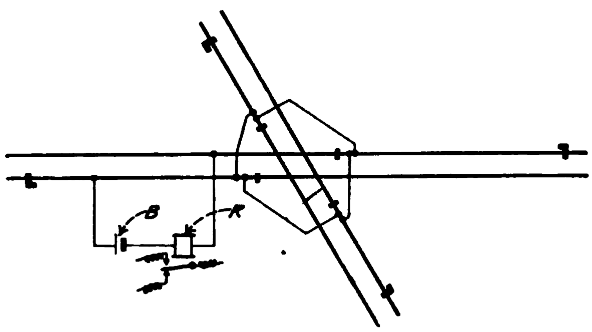


Fig. 341. Application of Normally Open Track Circuit.

For the purposes of the above table the resistance of the rails, and of the battery and relay leads is disregarded, also that of the ties and ballast. In calculating the table Ohm's law is used in the form $I = \frac{E \times 1000}{(B + R)}$, where I is the current, in mil-amperes, E is the electro-motive force in volts, B the internal resistance of the battery in ohms, and R the external resistance of the circuit (relay) in ohms. The factor 1000 is used in the numerator to reduce the result to mil-amperes. Where cells are placed in multiples or parallel the internal resistance of the battery is reduced in proportion to the number of cells; two cells reduce it to ½, three cells to ⅓, etc. Where cells are placed in series the internal resistance is increased proportionately to the number of cells; with two cells it is twice as much, three cells three times as much, etc.

The electrical characteristic of the various arrangements is shown in the table. Their mechanical characteristics will now be considered. Fig. 329 is seldom used for the reason that should the jar break or any other accident happen to the cell, the circuit would fail to operate. Fig. 330, two cells in multiple or parallel, is the usual arrangement. It guards against failures as the chances of accident to both cells at the same time is remote. Also the cells can be renewed alternately, thereby assuring a uniform output of the battery as a whole. Fig. 331, three cells in parallel, is a further development of Fig. 330. It also secures a slightly lower internal resistance with consequent increased output. Fig. 332, two cells in series, like Fig. 329, is rarely used, and for the same reason. Fig. 333, two cells in multiple with one in series, is rather liable to failure, but has electrical advantage as can be seen from the table. With this arrangement it is customary to rotate the cells from one place in the battery to another at the times of inspection and renewal. Fig. 334, four cells in series-multiple, is frequently used for long or wet sections; it will be noted that it is a development of Figs. 330 and 332. Fig. 335 is a development of Fig. 333, and Fig. 336 of Fig. 334.

The use of secondary or storage battery has been referred to. When this is used it is necessary to insert a resistance in one or both battery leads to restrict the flow of current and prevent the battery from becoming exhausted by the passage of one train, and otherwise injured by over-discharge, as explained in the definition of storage batteries.

Where it is necessary to control signaling apparatus by track circuits over such a length of track that one circuit would not work, two or more circuits are employed. The control circuits may be broken through the relays of the successive track circuits, or "cut sections" may be introduced. Fig. 337 shows this latter arrangement, which consists of two adjacent track circuits, one controlled by the other. Fig. 338 shows a train in the first section. The relay R′ of the second section breaks and shunts the circuit of the first section when the train is in the second (Fig. 339). As with the single track circuit, results are practically the same whichever way the train is moving. It should be noted that the shunting effect of the back contact point of relay R′ is applied to the track and not to the battery. This is to shunt out any foreign current that may have leaked into the section and would be liable to energize the relay R; it also prolongs the life of battery B.

The track circuits above considered were normally closed. Normally open circuits are also used to a limited extent. Fig. 340 shows such a circuit. Here the relay is normally de-energized as there is no connection between the rails. The presence of a train on the circuit, Fig. 340a, picks up the armature opening or closing control circuits through its contact points. Current flows from positive side of battery to one rail, through wheels and axles of train to other rail, through the relay and back to battery. This kind of circuit is used principally for annunciators. An application to a crossing is shown in Fig. 341. Here only one rail in each part of the circuit is insulated, but this does not in any way affect its

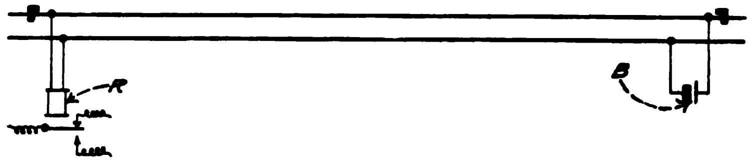


Fig. 342. "Single Rail" Track Circuit, Normally Closed.

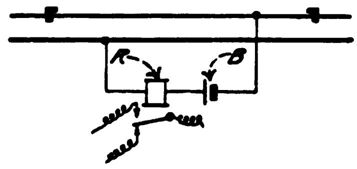


Fig. 343. "Single Rail" Track Circuit, Normally Open.

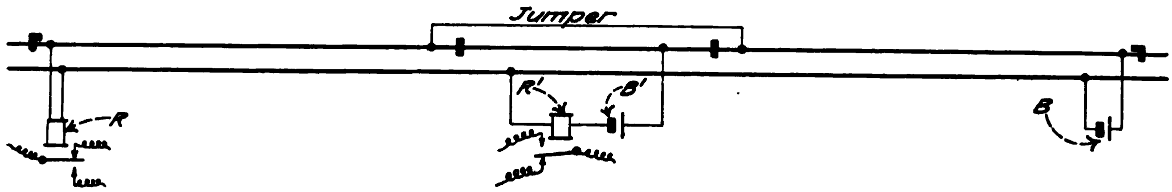


Fig. 344. Normally Closed Track Circuits, with Normally Open Track Circuit Superimposed.

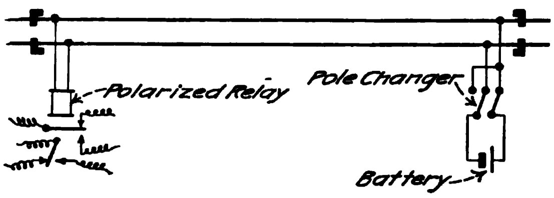


Fig. 345. Simple Polarized Track Circuit; Pole Changer Nominal.

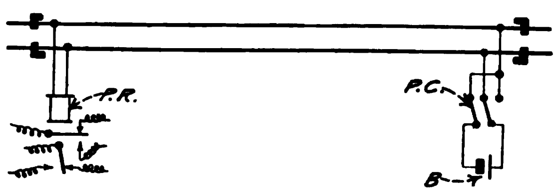


Fig. 345a. Simple Polarized Track Circuit; Pole Changer Reversed.

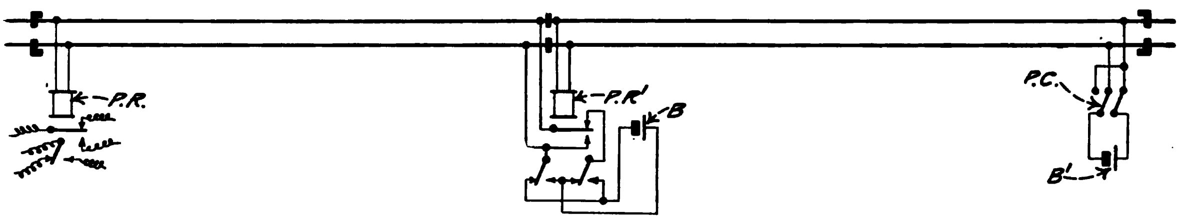


Fig. 346. Cut Section, in Polarized Track Circuit; Pole Changer Normal.

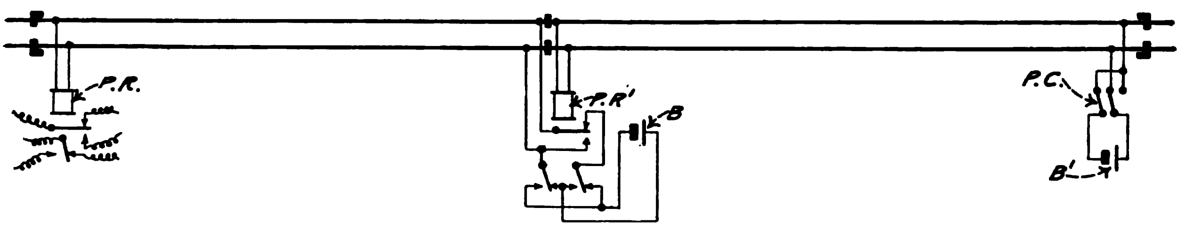


Fig. 347. Cut Section, in Polarized Track Circuit; Pole Changer Reversed.

operation. A train on any track between the insulated joints will complete a circuit as in Fig. 340a. In normally open track circuits the resistance of the relay should be lower than in normally closed. Their use is necessarily limited to track sections of a few rail-lengths only; in longer sections the low insulation resistance from rail to rail would allow the flow of enough current to hold up the relay after a train had passed out of the section. Gravity battery should not be used unless the traffic is very heavy, as a gravity cell soon deteriorates and becomes inoperative on an open circuit.

The use of normally open track circuits is also limited on account of the fact that there is no certainty that the relay will pick up. Any failure of the apparatus, such as a broken rail, exhaustion or breakage of the battery cell, breakage at any of the wires will render the apparatus inoperative. Such failures are not readily detected as they merely maintain the apparatus in its normal condition. With a normally closed circuit the reverse is true. Here any failure will be almost immediately detected, and will be on the side of safety.

Figs. 342 and 343 show the same circuits as Figs. 326 and 340, except that only one rail is insulated; they are sometimes termed "single rail" circuits. Installations of this kind are made to avoid the expense of two insulated joints or where one rail is needed for another circuit. Such track circuits are more liable to failure than those having both rails insulated for the reason that the breakdown of one insulated joint will extend the circuit beyond its proper limits and cause interference with neighboring circuits and premature or extended shunting of the relay due to the presence of a train beyond the insulated joints.

Fig. 344 is a special arrangement. A normally open track circuit is placed within the limits of a normally closed circuit. This shows one advantage of insulating only one rail. The uninsulated rail is common to both circuits and the necessity of a second "jumper" to carry one circuit past the other is avoided. Such an arrangement might be used when it is necessary to announce a train from some point within a signal track circuit.

In Figs. 345 and 345a is shown a track circuit in which the direction or "polarity," as well as the presence of current is made use of at the relay. By this means two separate functions may be performed by one track circuit, provided that the first or principal function, actuated by the presence (or absence) of current, does not interfere with the secondary function, actuated both by the presence of current and its polarity. For example, in a two-arm (home and distant) automatic signal, the home signal is controlled by its immediate track circuit, while the distant must be controlled by this circuit and the position of the next home signal in advance.

In place of the ordinary track relay, one of special design called a polarized relay is used. Such a relay is constructed like an ordinary track relay, except for the addition of a polarized armature. In its simplest form this armature would consist of a permanent magnet, one extremity of which would be free to swing between the pole pieces of the electro-magnet. As like magnetic

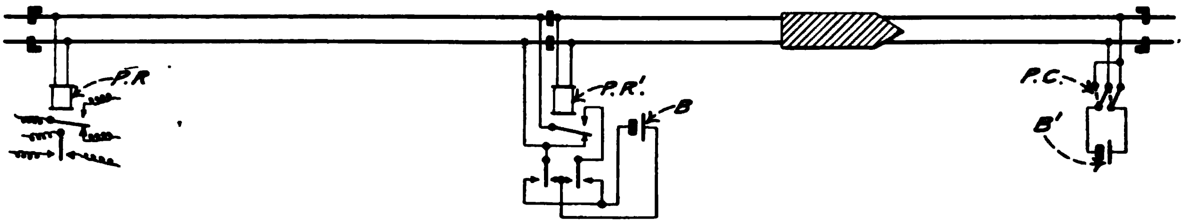


Fig. 348. Polarized Track Circuit with Cut Section, Relaying Section Occupied by Train.

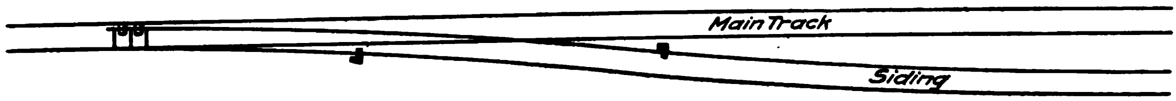


Fig. 349. Wedged Switch in Track Circuit.

Switch rail separated by wedges from electrical connection with main rail.

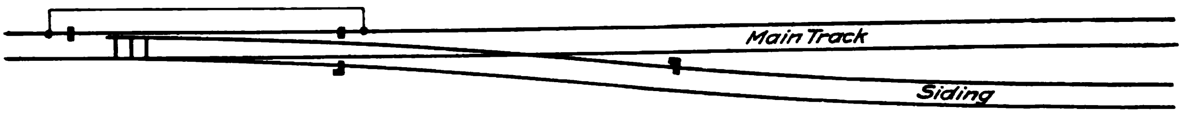


Fig. 350. Switch in Track Circuit; One Rail Cut Out.

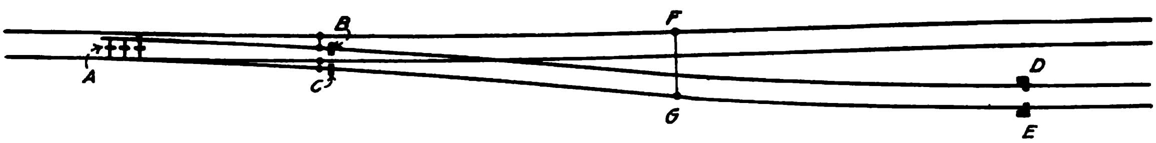


Fig. 351. Insulated Switch, with Siding Rails Electrified to Fouling Point, DE.

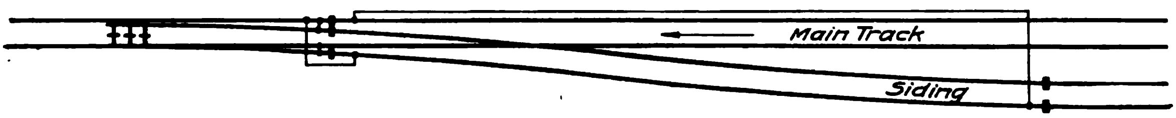


Fig. 352. Insulated Switch, with Fouling Protection. Chicago & North-Western.

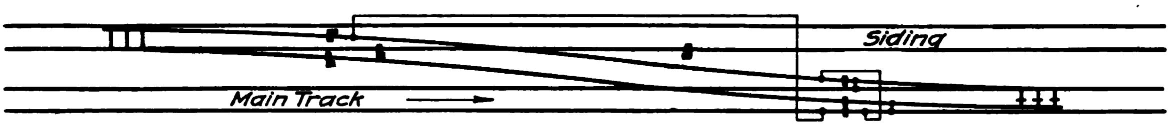


Fig. 353. Siding Crossover in Track Circuit. Chicago & North-Western.

poles repel each other and unlike attract, and as a reversal of the direction of flow of current in the coils of an electro-magnet reverses the polarity of the magnet, it can readily be seen that with the track circuit flowing in one direction, the polarized armature would be attracted to one pole of the magnet, and vice versa. Change of direction in the track circuit current is affected by the pole changer shown. This is actuated by any desired means, such as a lever, signal arm, etc. Current flows from positive side of battery through left-hand arm of pole changer, through lower rail, relay, upper rail, right-hand arm of pole changer, back to battery. The polarized armature carrying contacts is deflected to the left and makes contact with the front point. With the pole changer to be reversed (Fig. 345a), current flows from positive side at battery through the left arm of pole changer, upper rail, relay, lower rail, right-hand arm of the pole changer, back to battery, and the polarized armature is deflected to the right, making contact with the back point. It should be noted that in both cases the neutral or ordinary armature is attracted as in an ordinary track circuit. Thus a circuit entirely separate from one through the neutral points can be controlled from beyond the track circuit, by means of the track circuit itself without interfering with one through the neutral points.

Figs. 346 and 347 show how a "cut section" may be introduced into a polarized track circuit. Here a polarized relay is used at the end of the right-hand section to reverse the polarity of the circuit for the left-hand section. This relay acts exactly as above described with relation to the pole changer. Its polarized armature fingers are made to take the place of a mechanical pole changer, thus repeating the action of the mechanical pole changer to the left-hand section. Fig. 346 shows the normal condition of the two circuits, Fig. 347, their condition when the mechanical pole changer is reversed. It should be noted that the neutral point at the cut section relay breaks and shunts the circuit in the rear just as in an ordinary cut section (Figs. 337-339) to transmit the shunting effects of a train in the right-hand section to the other (Fig. 348).

Where switches occur in a track circuit, special means must be employed to prevent short circuiting through the switch rods, and leakage to the turnout rails. Fig. 349 shows the simplest method of accomplishing this. Wedges are placed under the normally open point; these wedges are not in contact with the main track rail or the tie plates. They raise the switch point off the tie plates when it is open, but allow it to rest on them when closed. Two insulated joints are installed in the turnout tracks, one just behind the heel of the frog and the other at the end of the stock rail. This method is objectionable for any metallic substance lodging between the wedges and tie plates will cause a short circuit.

Another method is shown in Fig. 350. One rail is cut out of the

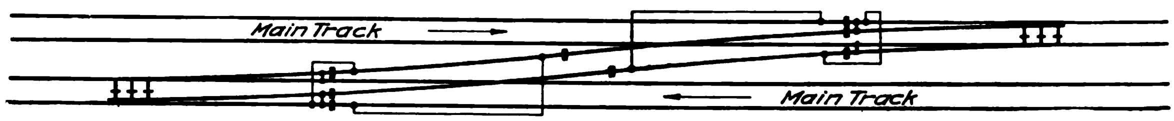


Fig. 354. Main Line Crossover in Track Circuit (Left-Hand Running). Chicago & North-Western.

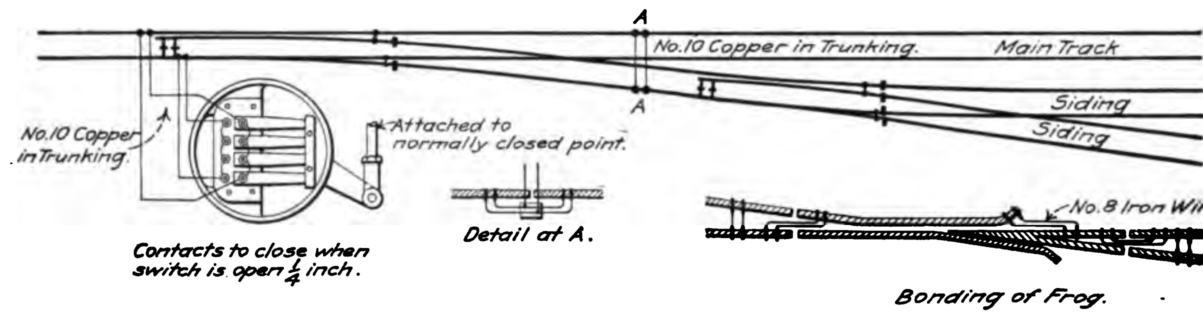


Fig. 355. Switch Wiring and Fouling Protection. Southern Pacific.

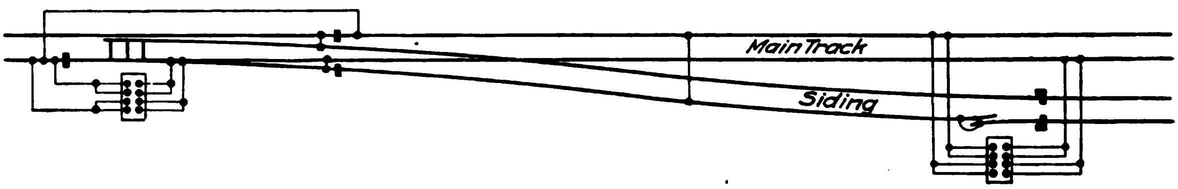


Fig. 356. Protection for Switch in Main Track and Derail in Siding.

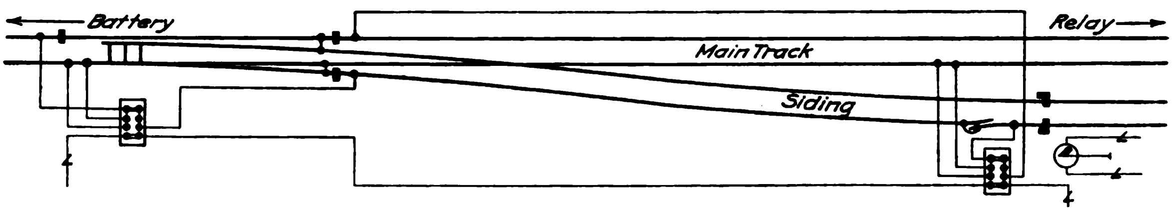


Fig. 357. Protection for Switch and Siding Derail; Siding Rail in Series.

circuit and a "jumper" used to carry the current around. The objection to this is that the dead rail might break and no protection be afforded. Also it requires two insulated joints in the main track, which is undesirable (because insulated joints in main track are somewhat expensive to maintain), and should be avoided when possible.

The most usual method is shown in Fig. 351. Here the switch rods, A, are insulated and the insulated rail-joints differently arranged. One is placed at C as above; another at B in switch rail between main track rails, and two others, D and E, at the fouling point of the turnout. The switch points are bonded to the stock rails to insure shunting by a pair of wheels on any part of the track. For the same reason the upper main line rail is connected to the lower turnout rail by the "jumper," F-G. This insures a shunt should a pair of wheels stand anywhere within the fouling point. It is desirable to have this jumper connect at the point G, midway between the insulated joints, to insure maximum amount of live track in case of a broken rail between C and E. If this "jumper" were not used and the insulated joint, C, on the turnout dispensed with, both turnout rails would be of the same polarity and no shunt would be effected. The joints, B and C, should be opposite each other in order to avoid a dead section of track between them.

Fig. 352 shows a method of guarding against a broken wire or rail within the fouling distance on the turnout. Here an insulated joint is placed in the main track near the switch, and a jumper run from each side of it to the fouling section of the side track rail. This puts the turnout rails in series with the main track and a broken wire or rail would open the circuit. No provision is made for similar protection of the inner turnout rails, however. In Fig. 353 is shown how the above protection is applied to a siding crossover. Fig. 354 shows the same applied to a main line crossover.

All the above methods of running track circuit through switches show no protection against an open switch. Fig. 355 shows how such protection is usually provided. The wiring of the track is the same as shown in Fig. 351. An additional switch, however, occurs in the siding, and this is merely shunted in as far as the main line fouling point. Two wires are used for the jumper so as to give protection should one break. These are soldered to separate bond wires at a convenient joint (Detail A), because if they were tapped into the main track rail at separate points and the rail should break between them, there would be no protection against this broken rail. A detail of the frog bonding is also shown. This guards against a broken frog to a certain extent. Protection against an open switch is secured through the switch instrument or "switch box" shown in enlarged detail. The lever, moved by the rod attached to the normally closed point of the switch, brings the upper set of springs into contact with a similar set below them (not shown) when the point is open ¼ inch or more. The upper set of springs are connected by two wires to one rail of the main track and the lower set to the other rail, as shown. When the two sets of springs come into contact the result is the same as the presence of a train, namely, a short circuit. Four upper and four lower springs are used in multiple, to guard against failure of any one pair and to provide a low resistance circuit.

Fig. 356 shows a slightly different method of arrangement with the switch box shown diagrammatically. The track circuit is transposed and the contact springs shunt the circuit as above, but around the insulated joint instead of across the track. In this figure is also shown a switch box worked by a siding derail which shunts the main track rails when the derail is closed. The main track is shunted rather than the siding, because a broken wire or rail in the siding would render the shunt inoperative.

Fig. 357 illustrates a method of switch protection which is somewhat elaborate. Under normal conditions current flows from battery through upper rail to insulated joint, thence through jumper, upper pair of switch box contacts, through two middle right-hand switch box binding posts, through jumper, outside siding rail, through

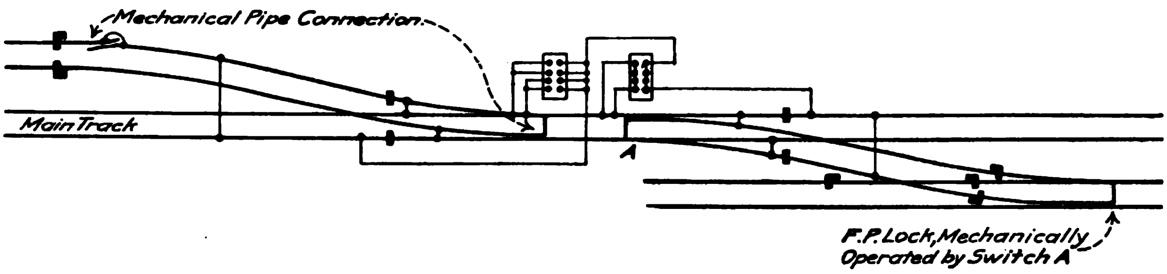


Fig. 358. Transposition and Protection for Two Switches.

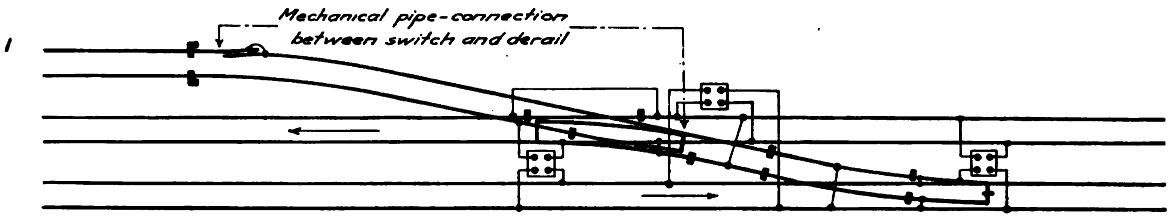


Fig. 359. Protection for Main Line Crossover and Slip Switch.

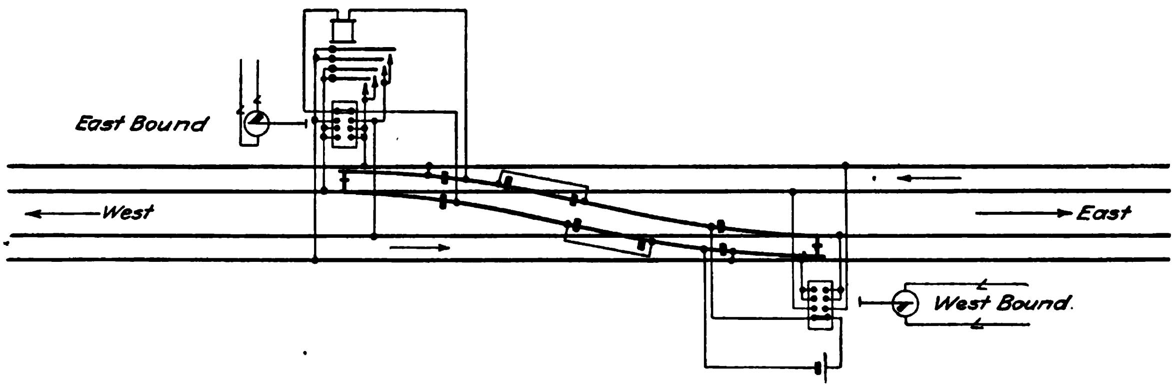


Fig. 360. Track Circuit for Main Line Crossover. Illinois Central.

derail switch box in same manner as first switch box, to upper main track rail, through relay, back on lower main track rail to battery. When either switch or derail is reversed the run around jumper circuit is opened and the relay shunted by the switch box. These switch boxes are provided with two normally closed and two normally open contacts instead of four normally open as in previous examples. In this figure a control circuit is shown carried through one pair of closed contacts in each box. This circuit would be broken with either switch or derail reversed. This represents a line wire controlling the signal and is provided as an additional precaution. A switch indicator is also shown at the derail.

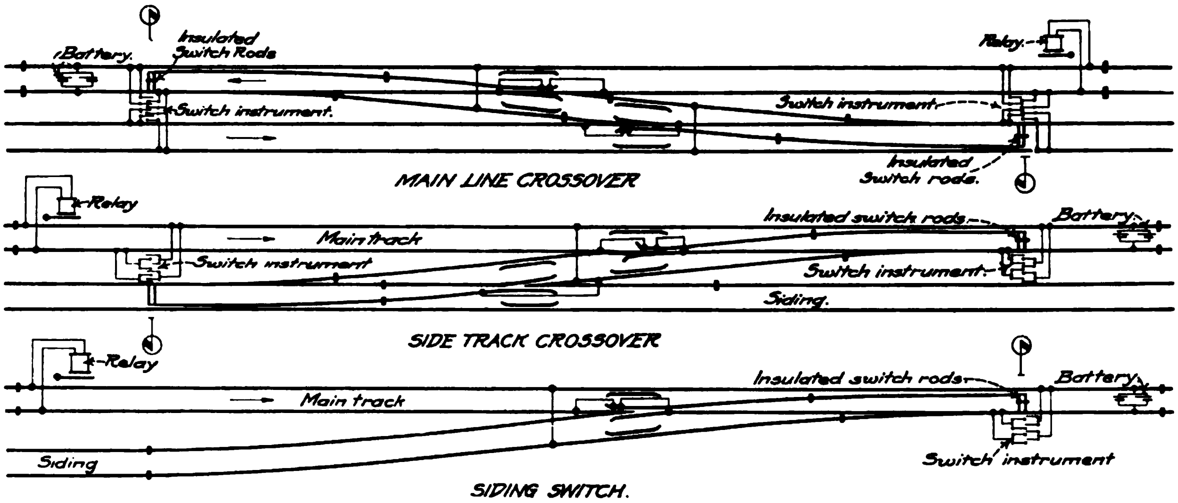
Fig. 358 shows two switches close together. Here the track circuit is transposed by means of a run around jumper between the switches. Current passes from upper rail right-hand side, through jumper to lower rail left-hand side and from upper rail left-hand side through frog, switch point, to lower rail through bond wires, also in parallel in a similar manner through the other frog and switch point. The switch boxes shunt the circuit. No switch boxes are used at the derail and siding switch because these are controlled mechanically from the main line switches. Many roads, however, use switch boxes even at both ends of pipe connected or plunger locked switches and derails as an extra precaution. Fig. 359 shows a similar arrangement as applied to a crossing with a single slip switch and crossover between two main tracks. All the switch boxes must shunt both main tracks because with any switch open a train might foul both tracks.

Fig. 360 illustrates what is perhaps the highest development of crossover protection. Here the rails of the crossover are made into a separate track circuit whose relay, when de-energized, shunts both main line circuits. The relay may also be made to break one or more signal control circuits, as was done by switch boxes in Fig. 357. The switch box wiring is the same as that illustrated in Fig. 355, except that one pair of springs in each box is normally closed and breaks the crossover track circuit with either switch open. It is obvious that a broken crossover rail will cause the shunting of both main line circuits, also that a single engine or car standing on the crossover with both switches closed would produce the same result.

Figs. 361-363 show the New York Central standard circuits for switch protection. They are all similar to Fig. 355.

Where one track crosses another at grade means must be provided to carry the track circuits through or around the crossing frogs. Figs. 364-367, inclusive, illustrate how this may be done. In Fig. 364 the horizontal track circuit goes through and the other is carried around the frogs by jumpers. In Fig. 365 there is only one circuit, which is transposed at the frog. Fig. 366 is used instead of Fig. 364, when the crossing is at or near a right angle and insulated cannot easily be placed in the frog rails. Fig. 367 is a development of Fig. 366, and is the most usual method, nevertheless in order to guard against broken rails or frogs it is desirable to have as little dead track as possible.

Fig. 368 shows how single rail circuits (see Figs. 342-344) may be used where there is foreign current that might interfere with a two-rail circuit. The cross bonding beyond the track circuit does away with any difference of potential which might otherwise exist between the rails, and the foreign current is carried past through the lower rail, which is made common to all the track circuits. Fig. 369 shows another method of accomplishing the same results, which may be used with a short isolated circuit. While allowing both rails to be used for a track circuit the cross bonds are installed as above, and foreign current is carried past through a jumper connecting these bonds. In Fig. 370 is shown an electric railroad crossing two tracks of a steam road. The track circuits of the steam road are carried around as in Fig. 367, but to avoid leakage as far as possible the trolley track is cross bonded on each side of the frogs to prevent any difference of potential that might otherwise exist between the rails, and all members of the frogs are bonded together and to the heavy central jumper connecting the cross bonds.



Figs. 361-363. Switch and Crossover Protection. New York Central & Hudson River.

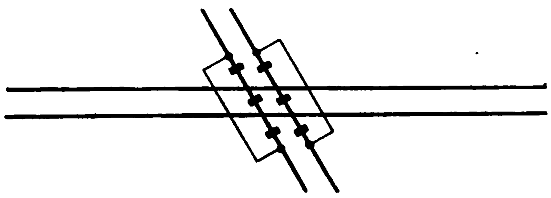


Fig. 364. Track Circuits Through Crossing; Two Rails Continuous.

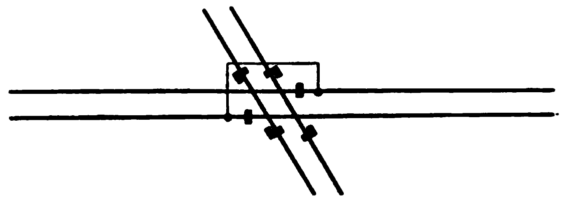


Fig. 365. Transposition of Track Circuit at Crossing.

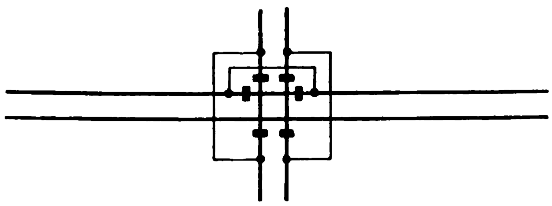


Fig. 366. Track Circuits Through Crossing; One Rail Continuous.

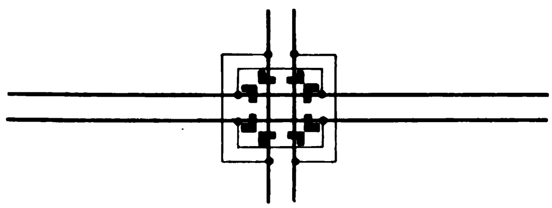


Fig. 367. Track Circuits Through Crossing; Four Jumpers.

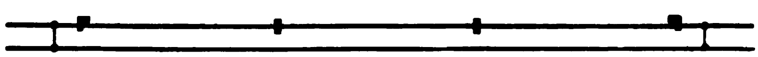


Fig. 368. Protection against Foreign Currents; "Single Rail" Track Circuits; Jumpers at Each End.

Fig. 369. Foreign Current Protection; Isolated Two-Rail Track Circuit.

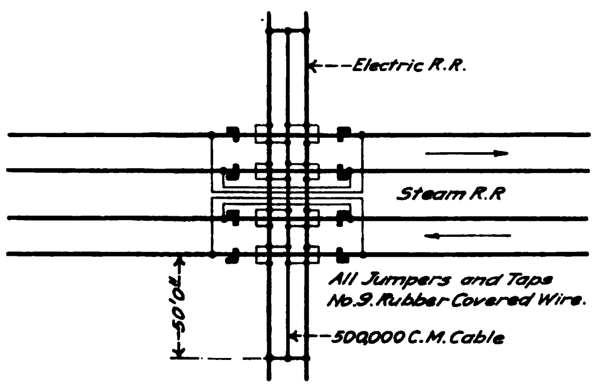


Fig. 370. Bonding at Crossing of an Electric Railroad. Chicago & North-Western.

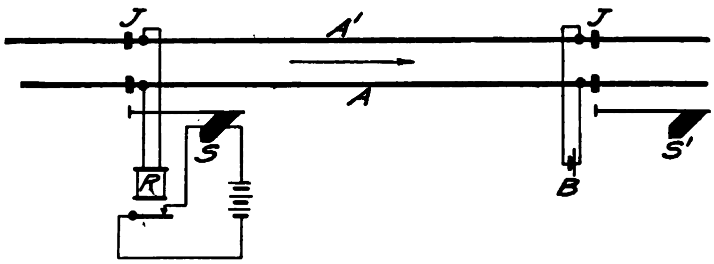


Fig. 371. Arrangement of Track Circuit and Connections for Normal Clear Automatic Block Signal.

In Fig. 371, if a car or train occupies the track between the insulated joints, J, J, it shunts the relay R. This allows its armature to drop, opening the local circuit, de-energizing the magnet, which, when energized, holds the signal in the clear position.

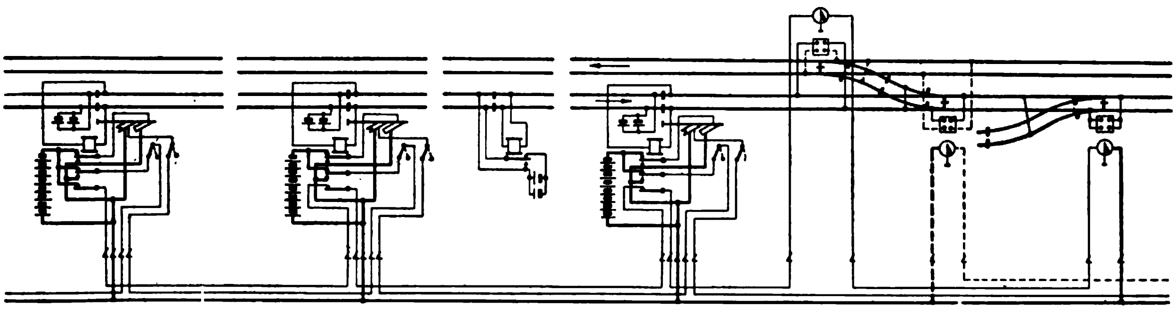


Fig. 372. Arrangement of Circuits for Normal Clear Automatic Signals; Line-wire Control for Distant Signal.

In Fig. 372 the home arms are controlled as shown in Fig. 371. Each home arm when moved, moves its two circuit controllers; one to control the circuit to its distant signal, one block in the rear, and the other to control the distant arm on its own post. For control of the distant one block back, current flows from the main battery through the second contact on the track relay, to the circuit controller, and thence over the line to and through one of the controllers at the signal in the rear and to the electromagnet there controlling the distant arm; thence back over the common return wire. The control by a home signal of the distant arm on its own post (which primarily is controlled by the home arm one block in advance), is to avoid an apparently inconsistent indication when the home arm is at stop, while the distant, so far as its own section is concerned, might be clear. The home arm can put the distant to caution, but cannot clear it, except when the home arm in advance is clear. Switch indicators are shown connected in series, operated by contacts on track relays.

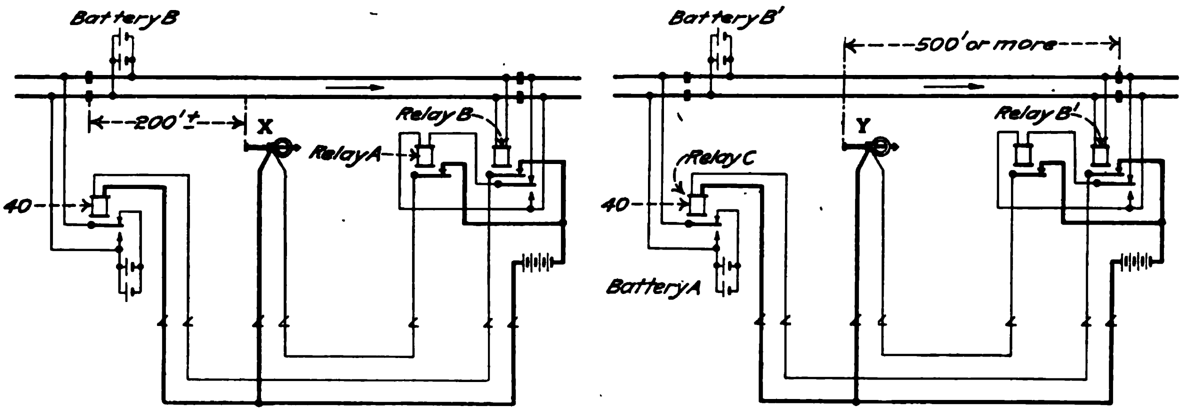


Fig. 373. Arrangement of Circuits for Normal Clear Clockwork Disk Signal, with Overlap. The Union Switch & Signal Company.

In Fig. 373 are illustrated the control circuits for the clockwork disk signal, Figs. 399-400. The signal is placed within the block as shown, the object of this being to allow the engineman to see the signal go to the stop position for his train. If it does not change before he reaches it, he is to regard it as a stop signal. As a train, approaching signal X, passes the insulated joints near battery B, it shunts relay B, which controls relay A through its lower armature contact. Relay A is de-energized and breaks the circuit which is holding signal X clear, and the signal assumes the stop position. Thus, if either relay for any reason fails to open, the signal will remain in the clear position and the engineman will regard it as if it had been in the stop position when he approached. As the rear of the train passes the next pair of insulated joints, relay B picks up but relay A remains de-energized, because the train now occupies the track circuit from which it receives energy, and signal X consequently remains in the stop position. When the train passes the insulated joints near battery B', relay B' is de-energized, causing signal Y to go to the stop position (as already explained) and also de-energizing the 40-ohm line relay, C, which is controlled through the upper armature contact of relay B'. Relay C in turn opens battery A, which is the source of energy for relay A, therefore relay A still remains de-energized, holding signal X in the stop position. When the train passes the last pair of insulated joints shown, relay B' picks up, energizing relay C, which closes battery A and energizes relay A, restoring signal X to the clear position.

Thus each signal is provided with an "overlap" which holds it in the stop position until the train has passed a point 500 feet (or more) beyond the next signal in advance.

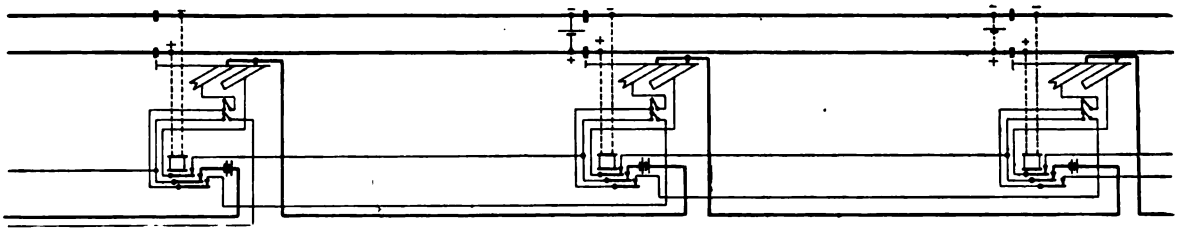
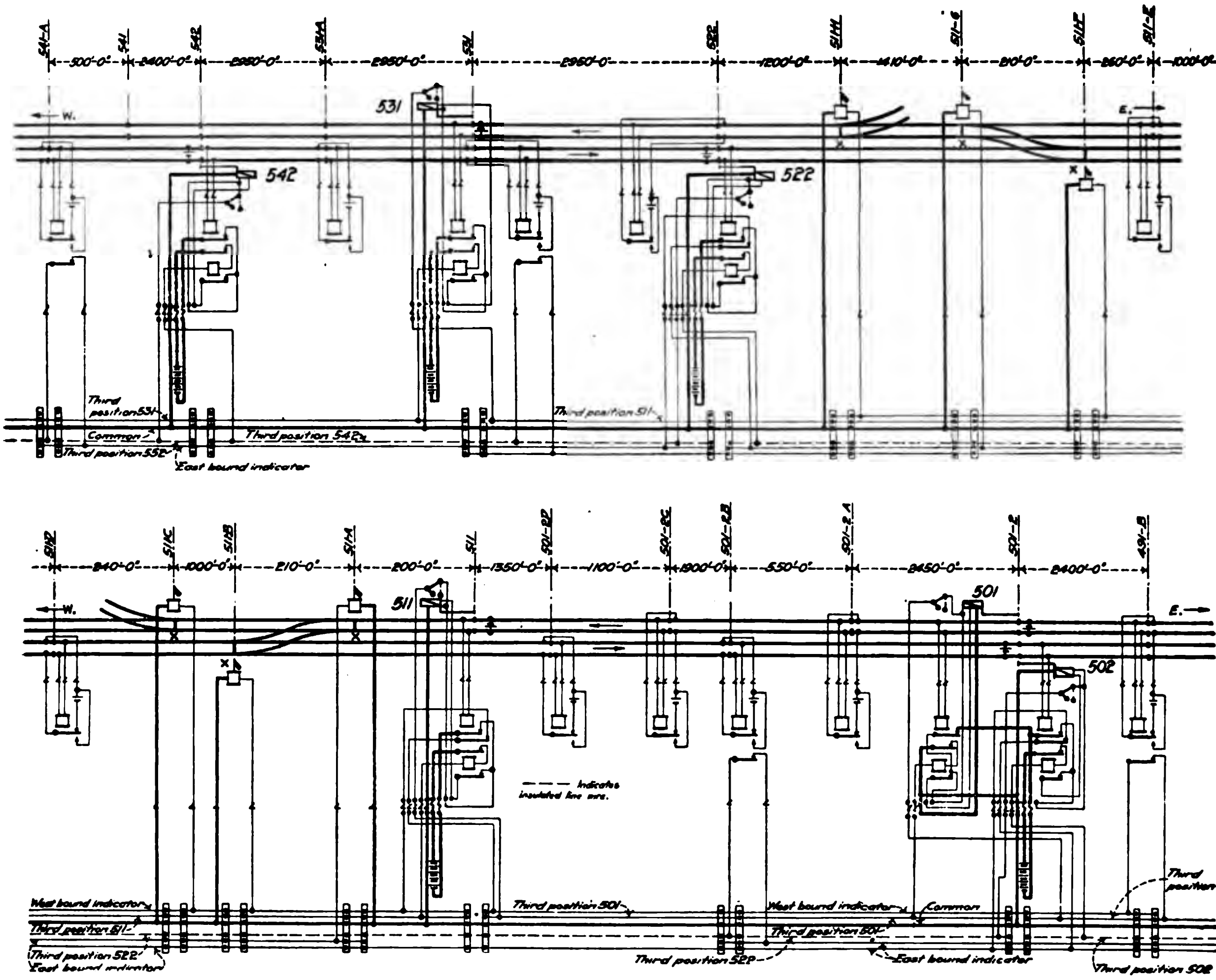


Fig. 374. Normal Clear, Line-Wire Distant Control and Full-Block Overlap. Pennsylvania Railroad.

Same as Fig. 372, but with each home signal controlled by the track relay of two blocks in advance, instead of only one. Thus the home signal at the extreme left of the drawing is controlled primarily by (1) its own track relay, and (2) through a wire from the track relay of the block in advance.



Figs. 375-376. Arrangement of Circuits for Normal Clear Three-Position Signals (Upward Inclination) on the Great Northern Railway. General Railway Signal Company.

THREE-POSITION SIGNALS, LINE CONTROL.

Figs. 375 and 376 are continuous with one another and show diagrammatically the circuits used in a normal clear automatic signal installation on the Great Northern. The signals are the General Railway Signal Company's three position upper quadrant type similar to those shown in Figs. 429-434. The 45° or caution position of each signal is controlled by the points of the track relay at the same location. The 90° or clear position is controlled by a line relay whose circuit originates at the signal in advance. For example, the control circuit for the line relay at signal 542 takes energy from the battery at signal 522. Through the track relay and to the signal it is part of the circuit which controls the caution position of signal 522. Just before reaching the signal, a tap is taken off and carried through the circuit controller (closed in caution and clear positions) over line wire, marked "third position 542," through coil of line relay at signal 542, through the lower contact on the track relay there, and to common. Track sections are relayed through cut sections when necessary. Switches are protected by extending the track circuits to the fouling point and shunting through switch boxes. Switch indicators are provided. They are controlled by circuits tapped off of the third position circuit for the signal two blocks in the rear, carried through a point of the last cut section relay in that block, point of track relay for block governed, through the indicator, to common. Indicators are connected in multiple. With this circuit warning is given at the switch when train is approaching second signal in the rear and if the switch is opened the train is given a caution indication at that signal and a stop indication at the home signal for the block in which the switch is located.

THE POLARIZED "WIRELESS" SYSTEM.

Figs. 377-379 show how the polarity of a track circuit is used by the Union Switch & Signal Company in the control of signals.

In Fig. 377 the home and distant signals are on the same post. The home signal is controlled directly by contacts on the neutral armature of the track relay. The distant signal circuit is passed through this contact on the neutral armature and also through the one on the polarized armature. The distant signal is, therefore, put in the caution position, either by home track circuit or by the home signal in advance, which reverses the polarity of the track circuit by means of the pole changer; it is also put to caution whenever the home signal on the same post goes to stop, by means of a circuit controller operated by the home arm.

The presence of a train in the section de-energizes the track relay and both arms assume the horizontal position. This is also done by the opening of a switch as shown near the right of the

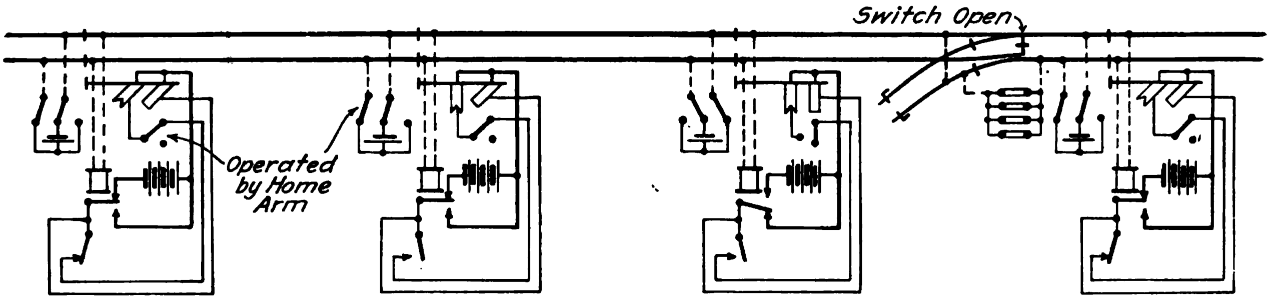


Fig. 377. Arrangement of Circuits for Normal Clear System; Distant Signals Controlled by Polarized Track Circuit. The Union Switch & Signal Company.

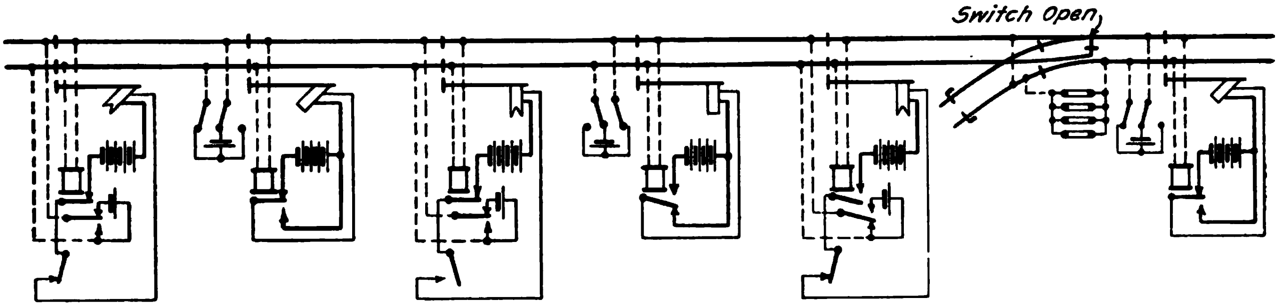


Fig. 378. Circuits for Normal Clear System, Polarized Track Circuits Controlling Distant Signals on Separate Posts. The Union Switch & Signal Company.

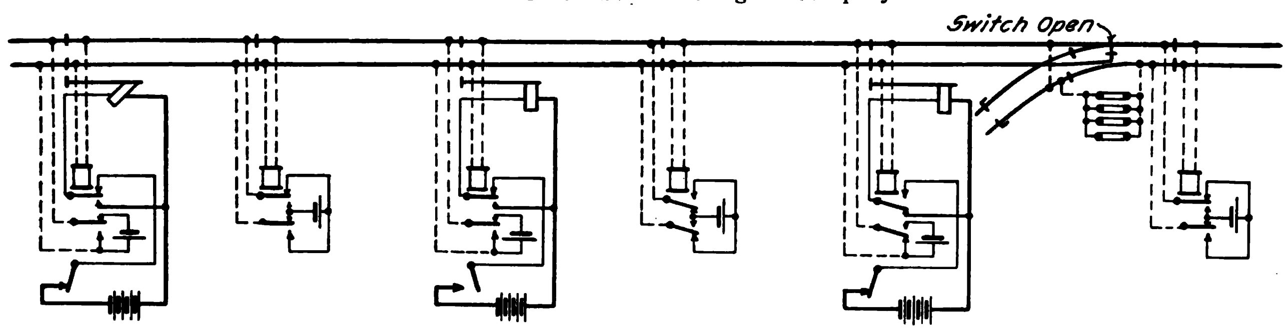


Fig. 379. Circuits for Normal Clear System with Overlap, No Distant Signals; Polarized Track Circuit Controlling Home Signals. The Union Switch & Signal Company.

figure, the track circuit being shunted through the contacts in the switch box (see Fig. 355).

At the signal on the extreme left of Fig. 377 all parts of the apparatus are in their normal position. The relay is energized with current of the right polarity to close its polarized contact, and the circuits for both arms are closed, holding them clear. At the second signal from the left the relay is energized, but with current of the wrong polarity to close the polarized contact. The circuit for the home arm is closed (by the neutral contact), but the circuit for the distant arm is broken at the polarized contact which is open. At the third signal from the left, the relay is de-energized, being shunted by the switch box, mentioned above. This opens the circuit for both arms at the relay; the distant circuit is again broken by the circuit controller on the home arm. The pole changer, also operated by the home arm and controlling the current from the track battery, is here reversed, which results in the caution position of the distant arm at the next signal in the rear. At the signal on the extreme right the apparatus is normal.

If the switch should be closed the relay at the next signal in the rear (now open) would be energized, closing both contacts. The home arm clears at once and when clear completes the circuit for the distant arm on the same post; it also operates the pole changer. The pole changer is arranged to "snap" over, so as to allow the relay (at the second signal from the left) to be de-energized for only an instant when the change in polarity takes place. This closes the polarized contact, completing the circuit that clears the distant arm. By using the mechanism shown in Fig. 427, these circuits may be used for a three-position signal. The use of the back contacts on the relays is explained in connection with Fig. 420.

Fig. 378 is a circuit diagram for home and distant signals with polarized track circuits, where the distant signal is not on the same post with a home signal. The distant signal is controlled by the track circuit immediately in advance through a neutral contact of the relay, and by its home signal through the pole-changer. The home signal is controlled by both of the track circuits as one is relayed by the other at the distant signal.

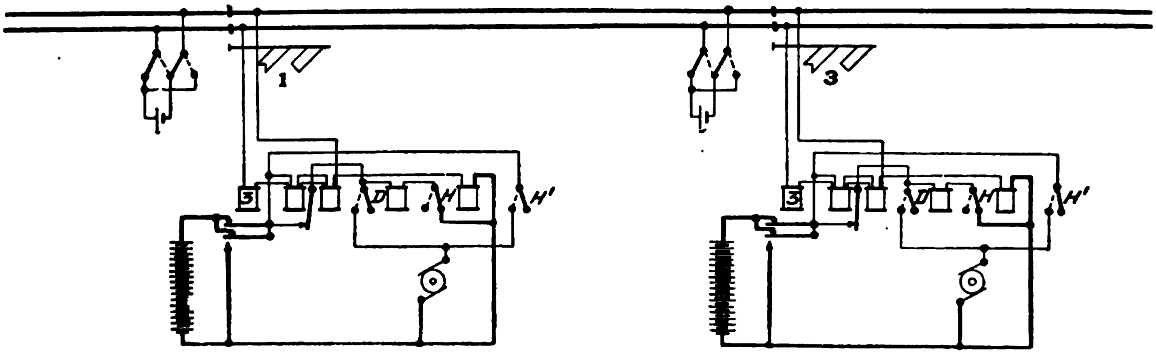


Fig. 380. Arrangement of Circuits for Normal Clear "Wireless" System, Distant Signals Controlled by Polarity of Track Circuit. Hall Signal Company.

Fig. 380 shows a "wireless" track circuit arrangement for automatic block signals designed by the Hall Signal Company.

The distant signal is controlled by a change of polarity in the track circuit acting on a special differential relay with six coils. Four of these are double wound, and the other two act as an ordinary track relay. The local signal battery acts on one set of windings and current from the track circuit on the other, in such a way that when the track circuit is normal the two circuits neutralize each other in two of the coils and act together in the other two. When the track circuit is reversed the coils formerly neutralized are energized and vice versa.

Only three of the coils are shown in the diagram. The relay marked 3 is the ordinary track relay. The armature controlling the distant arm is centrally pivoted between the four double wound coils.

Fig. 381 shows a wiring diagram for a relay box at a polarized cut section. The relay shown is the Union Switch & Signal Company's "Universal" type. Reversal of polarity in the second section is accomplished by means of a third cell of battery connected in opposition to the normal cells, as shown in the small diagram. A cell of the alkaline open-circuit type is usually employed, as it is active only for very short periods of time in comparison with an ordinary track battery.

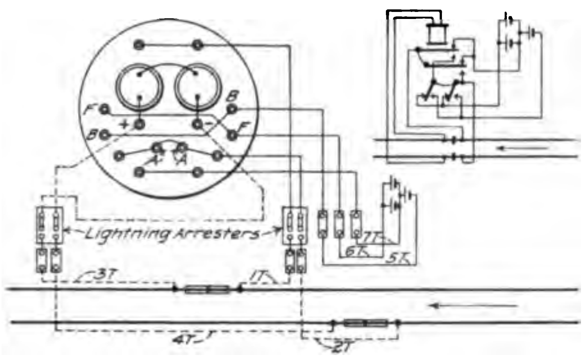


Fig. 381. Circuit Diagram for Polarized Cut Section, Effecting the Change in Polarity by the Use of Two Separate Batteries. Delaware, Lackawanna & Western.

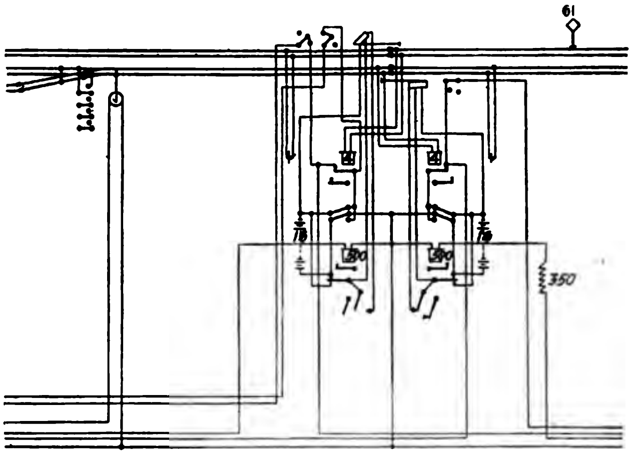


Fig. 382. Circuits for Normal Clear, Three-Position Signals, Batteries Feeding "With Traffic," Home Signals Controlled through Line Wires and Distant Signals by Polarity of Line Circuit. Rock Island System.

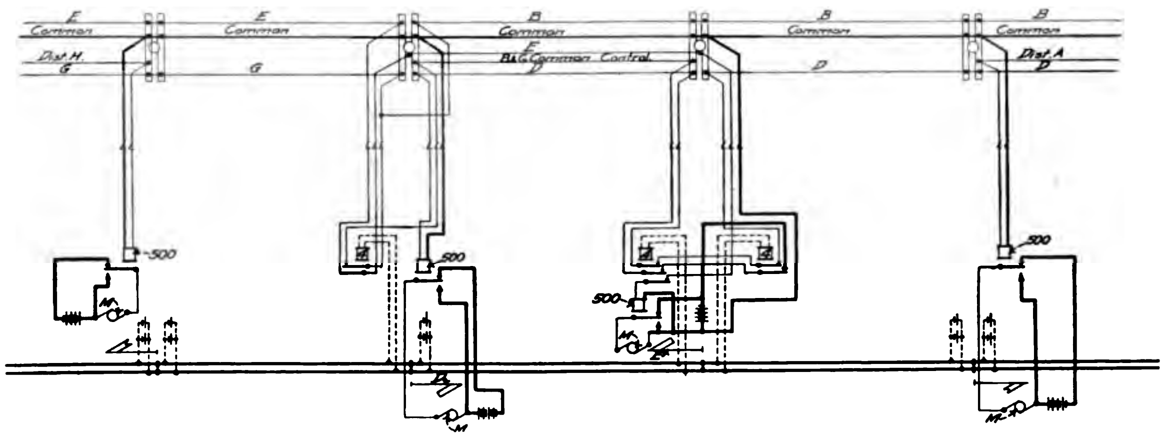


Fig. 383. Circuits for Normal Clear Automatic Signals on Single Track between Stations; Minimum Distance for Staggered Signals. Southern Pacific.

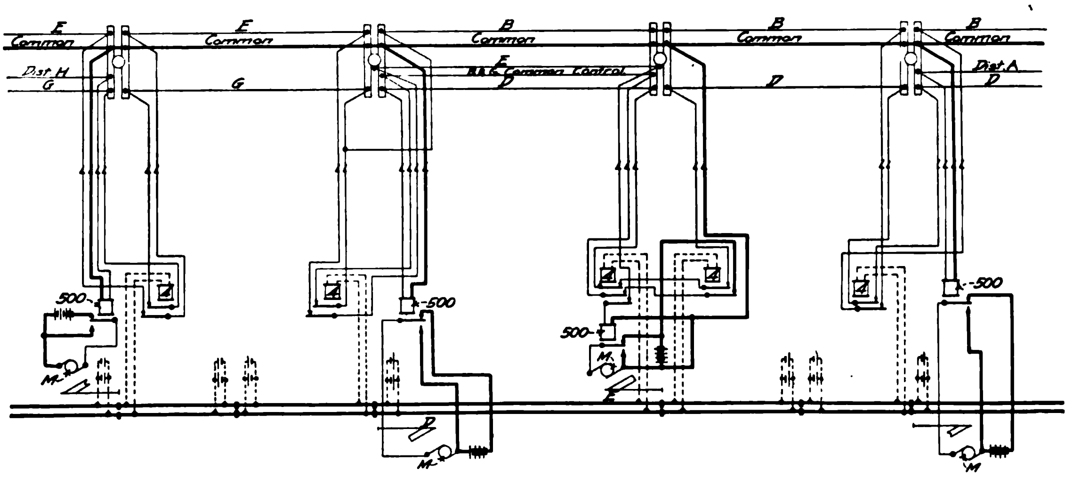


Fig. 384. Circuits for Normal Clear Automatic Signals on Single Track, Alternative Arrangement, Where Section between First Staggered Signal and Station Distant Signal is Too Great for One Track Circuit. Southern Pacific.

Normal clear three position automatic signals on the Rock Island system are controlled by polarized line circuits (Fig. 382). Track batteries are placed at the entering end of the sections. The local circuit for the first or caution position is controlled by the neutral points of a 500-ohm polarized line relay. This line relay is controlled by a circuit from battery at signal in advance, through a pole-changer operated by the second position of the advance signal, points of the track relay for the home section, over the line, to and through the 500-ohm relay to common. The third or clear position of the signal is controlled by the polarized points of this relay. With this system of wiring the positive side of one battery and the negative side of another may both be connected to common. Track circuits are not relayed, but when it is necessary to cut a section the circuit for the 500-ohm relay is carried through the points of the cut section relay. Switch indicators are controlled by circuit breakers on the signal arms and by the contacts on the track relays.

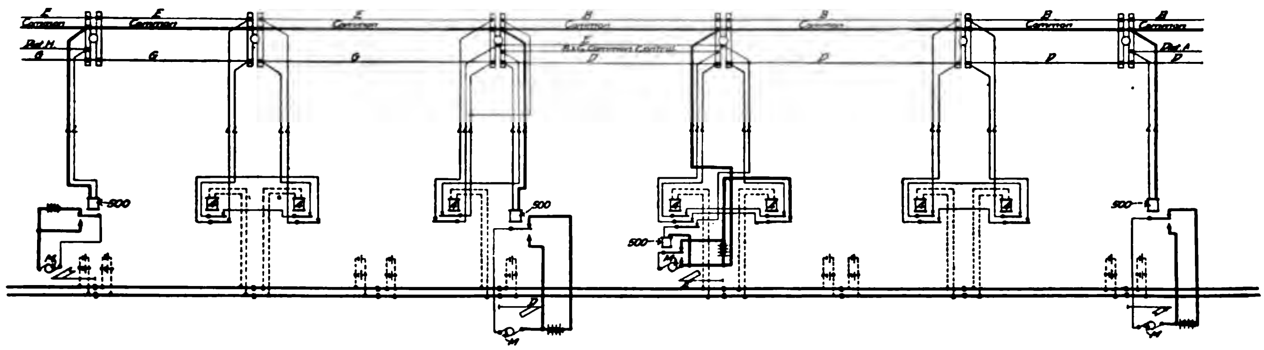


Fig. 385. Circuits for Normal Clear Automatic Signals on Single Track; Maximum Distance for One Pair of Staggered Signals. Southern Pacific.

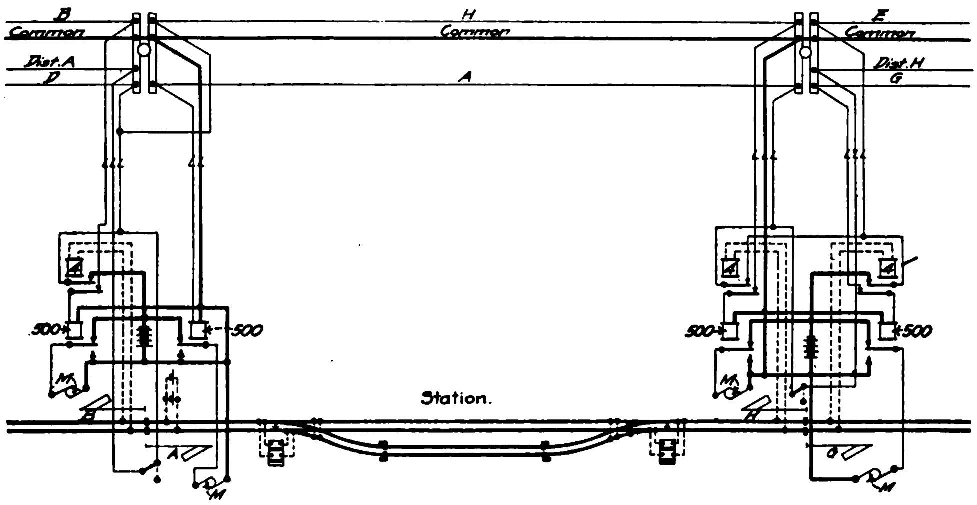


Fig. 386. Circuits for Normal Clear Automatic Signals at Stations on Single Track. Southern Pacific.

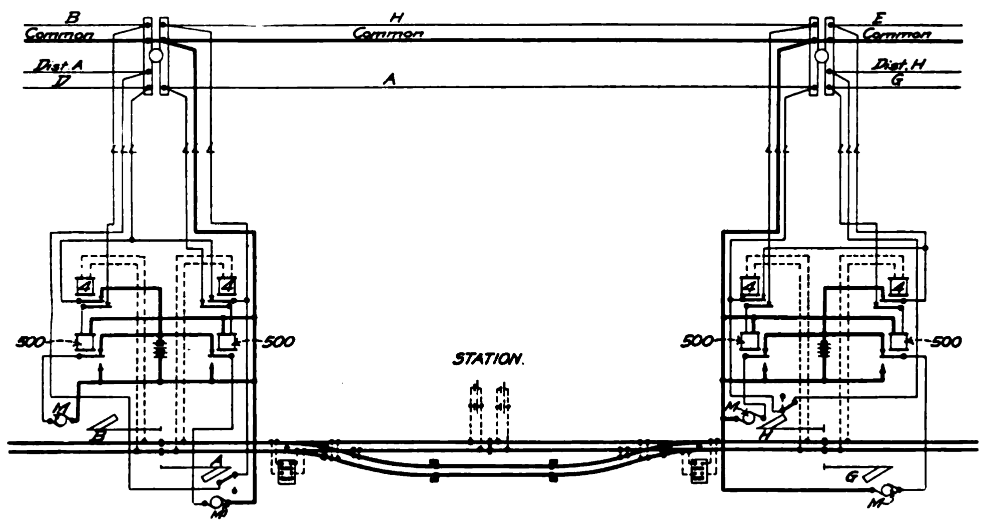


Fig. 387. Circuits for Normal Clear Automatic Signals on Single Track, to be Used Instead of Those Shown in Fig. 386, Where Section is Too Long to be Included in One Track Circuit. Southern Pacific.

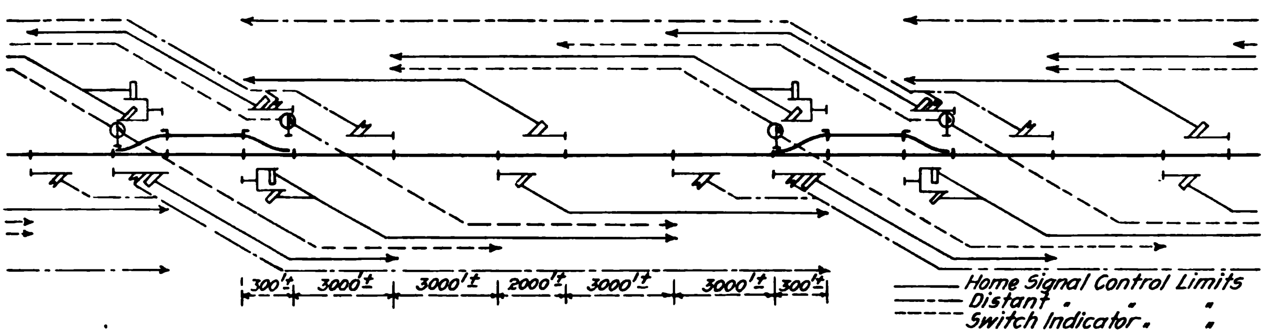


Fig. 388. Diagram of Normal Clear Automatic Signals for Single Track Showing Control Limits of Apparatus, as Used on the Ulster & Delaware. The Union Switch & Signal Company.

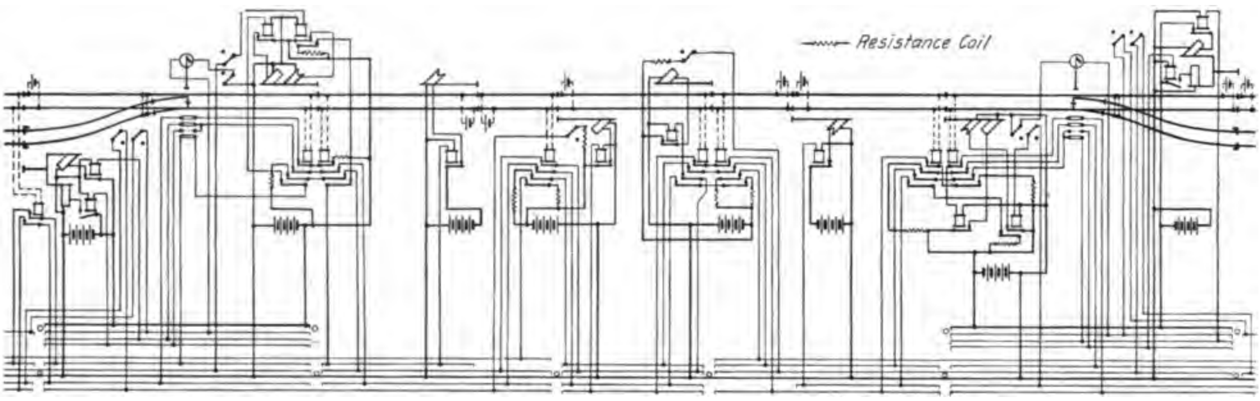


Fig. 389. Diagram of Typical Circuits for Signals Shown in Fig. 388. The Union Switch & Signal Company.

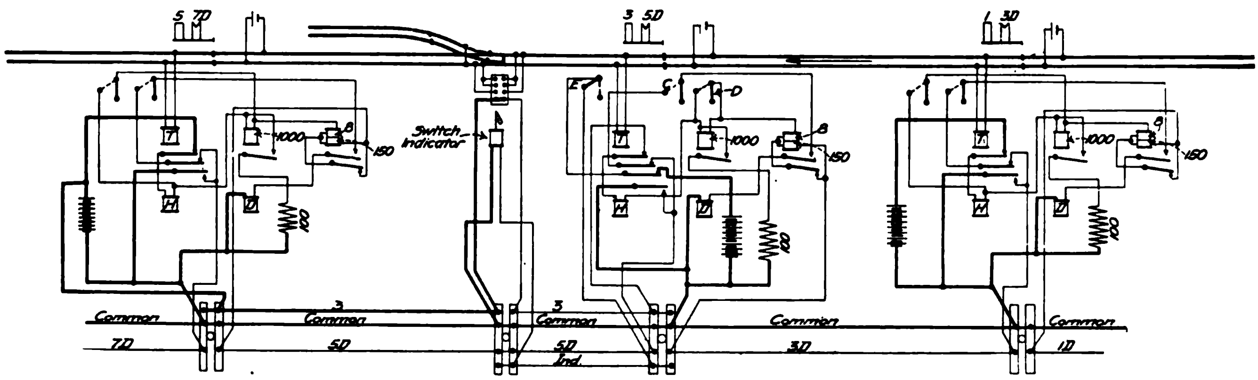


Fig. 390. Signal Control Circuits, Normal Danger Double Track Differential System. Hall Signal Company.

NORMAL DANGER CIRCUITS.

Fig. 390 is a diagram of circuits for a "normal danger" system designed by the Hall Signal Company, using a differential relay for clearing purposes.

Consider a train to be entering the first block (at home signal 1). Current passes from the battery at home signal 5, over line wire 3, through a normally closed contact in the switch box, to and through the upper front contact of the track relay at home signal 3, the home clutch, the coil of the 1,000-ohm relay, the 8-ohm coil of the differential relay, a back contact on the same relay, line wire 3 D, back contact of the track relay at signal 1 (now de-energized) to common. This energizes the 1,000-ohm relay, closing its front contact and thus providing a shunt circuit through the 100-ohm resistance at signal 3 to common; enough current, however, continues to flow through the original circuit to keep the 1,000-ohm relay closed. The home clutch at signal 3 is now energized causing that arm to clear (for local circuits see Figs. 411 and 450). Circuit controllers C and D are closed when signal 3 reaches the clear position. D shunts the coil of the 1,000-ohm relay, de-energizing it and reducing the resistance in the circuit through the 8-ohm coil of the differential relay, which allows enough current to pass through it to pick up its armature, opening the back contact which now cuts in the 150-ohm winding. The upper contact on the differential relay also closes and completes a circuit as follows: From battery at home signal 5, through upper front contact on track relay, home clutch, 1,000-ohm relay and 8-ohm coil and back contact of differential relay at signal 5, line wire 5 D, second front contact on track relay at signal 3, circuit controller C, front contact on differential relay (now closed) distant clutch, to common. This clears signal 5 in the same manner as already explained for signal 3, but when the 1,000-ohm relay (at signal 5) is shunted the differential relay will not at once pick up, because of the resistance of the clutch D (for signal 5 D), which is in series with the 8-ohm winding. However, enough current is now flowing to energize this clutch and clear the distant arm 5 D.

When the train passes signal 3, the track relay at that point is de-energized, opening the circuits through both the home and distant clutches at that point, and thus putting both arms in the horizontal position. The back contact on the track relay now connects wire 5 D direct to common, permitting enough current to flow through the 8-ohm winding of the differential relay at signal 5 to pick up its armature, as already described in connection with the differential relay at signal 3. This serves to clear the next signal in advance of 5 (not shown) which in turn permits distant signal 7 D to be cleared as already described for 5 D.

The switch indicator is controlled by the contact E, operated by home signal 3, and also by a front contact on the track relay at that signal. It will be noted that the use of the 1,000-ohm relay and shunt circuit (through the 100-ohm resistance) permits the same line wire to be used for controlling the distant signal that is used for clearing the home signal in advance of a train.

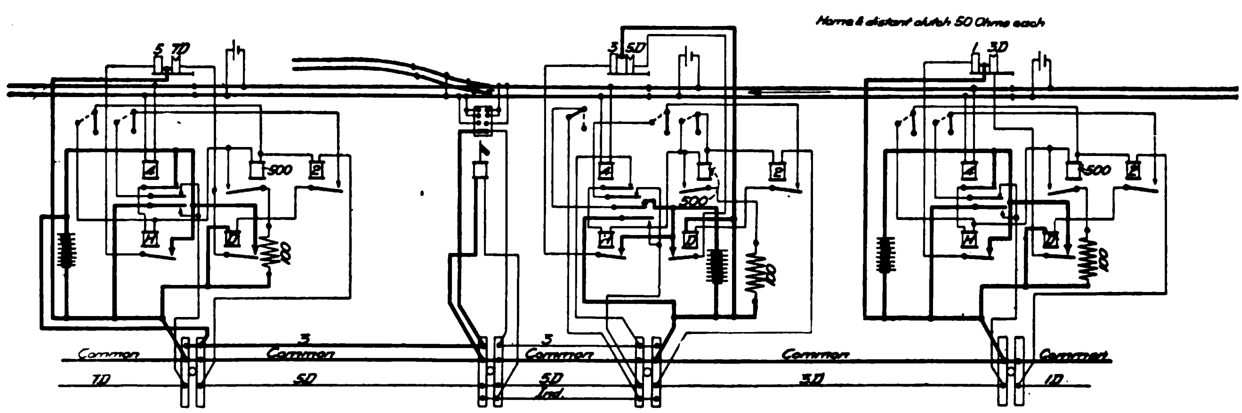


Fig. 391. Signal Control Circuits, Normal Danger Double Track Differential System. Hall Signal Company.

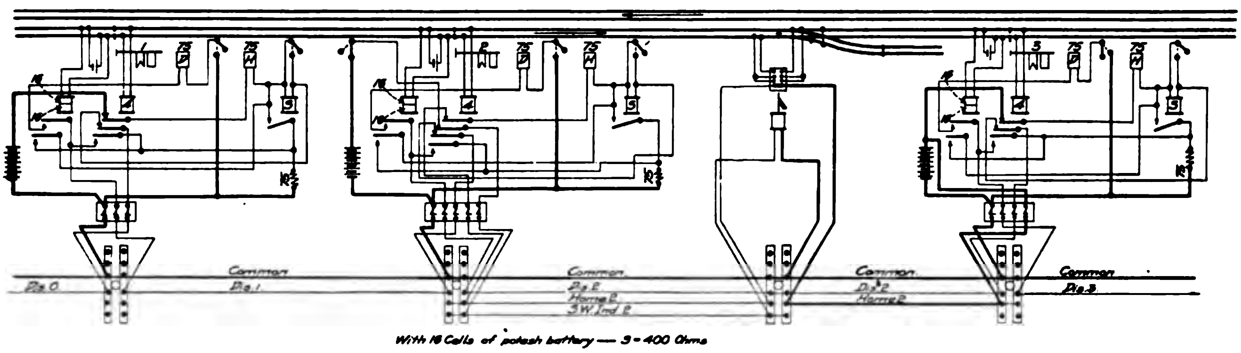


Fig. 392. Arrangement of Circuits for Normal Danger Double Track, with Clearing Relay.

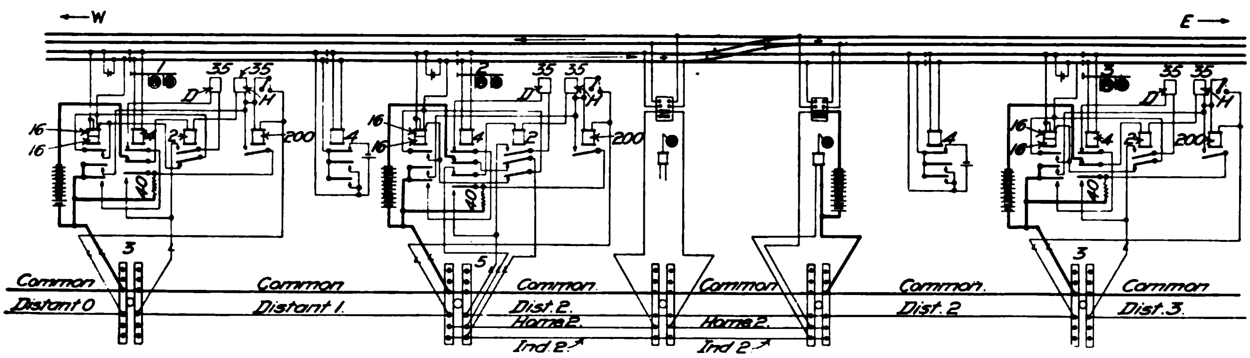


Fig. 393. Circuits for Normal Danger Double Track, Using Enclosed Disk Signal.

In Fig. 391, a 2-ohm relay is substituted for the 8-150 differential, and a 500-ohm relay in place of the 1,000; otherwise the circuits are the same and also the sequence of operation.

Fig. 392 shows circuits for a normal danger system using clearing relays operated by the track circuits. These clearing relays are compound wound, having two sets of coils each of 16 ohms resistance, so connected to the armature contacts that when the relay is energized one winding is cut out, and when de-energized both windings are connected in multiple.

Consider a train to be entering the first block at signal 1; the compound relay at signal 2 is de-energized and its lower back contact completes a circuit as follows: From battery at signal 3, through line wire (home 2), normally closed contact in switch box, upper front contact on the 4-ohm track relay at signal 2, home clutch, back contact (now closed) on the compound relay, 75-ohm resistance to common. This clears the home arm at signal 2, closing the two circuit controllers, shown near the home clutch magnet, and completing a circuit as follows: From the battery at signal 3, through the upper front contact of the 4-ohm relay, home clutch H, coil of relay S, second front contact on the 4-ohm relay, line wire (dis. 2), top back contact on the compound relay at signal 2, distant clutch D, circuit controller (now closed), to common. Relay S at signal 3 is now energized, closing a shunt circuit through the 75-ohm resistance to common; this leaves enough current passing through the coil of this relay to keep its armature from releasing. The home clutch at signal 3 is now energized and its arm clears, closing the two circuit controllers and shunting out the coil of relay S, whose armature now drops. With this coil shunted out enough current flows through the distant clutch at signal 2 to energize it and clear the distant arm at that point.

When the train passes signal 2, the 4-ohm relay at that point is de-energized, putting both arms in the horizontal position, but closing the line wire (dis. 2) to common through the 75-ohm resistance, by its back contact. This holds the home signal at 3 clear, in case the compound relay at that point should not be de-energized at once when the train enters its circuit. When the compound relay at 3 drops, the next home signal in advance (not shown) clears, as already explained for signal 3, and permits the distant arm 3 to clear. The switch indicator is controlled in the same manner as in Figs. 390-391.

Fig. 393 shows an arrangement of circuits for the enclosed disk signal similar to that shown in Fig. 392 for the semaphore, the principal difference being the substitution of a 2-ohm relay for the circuit controllers attached to the home signal. This relay is used on account of inconvenience in attaching reliable circuit controllers to the disk mechanism. It also closes, through a back contact, a path for current through one winding of the compound relay to insure its operation in case the back contact on the relay itself should not make good connection.

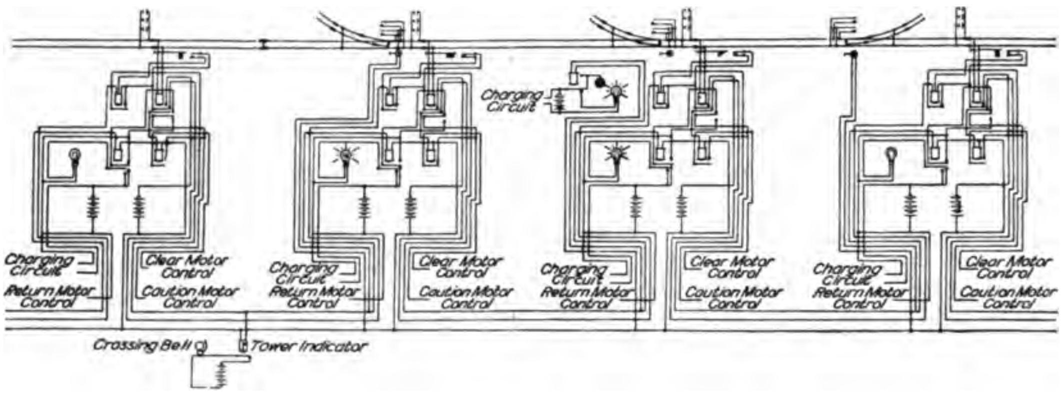


Fig. 394. Circuits for Normal Danger Three-Position Signals, with Electric Lights Burning Only on Approach of Train. Baltimore & Ohio.

On the Baltimore & Ohio there is an installation of normal danger automatic signals using a normally closed circuit for clearing signals in advance of a train. A distinguishing feature of this installation is the use of electric lights in the signals which burn only when a train is approaching. Typical circuits for this installation are shown in Fig. 394.

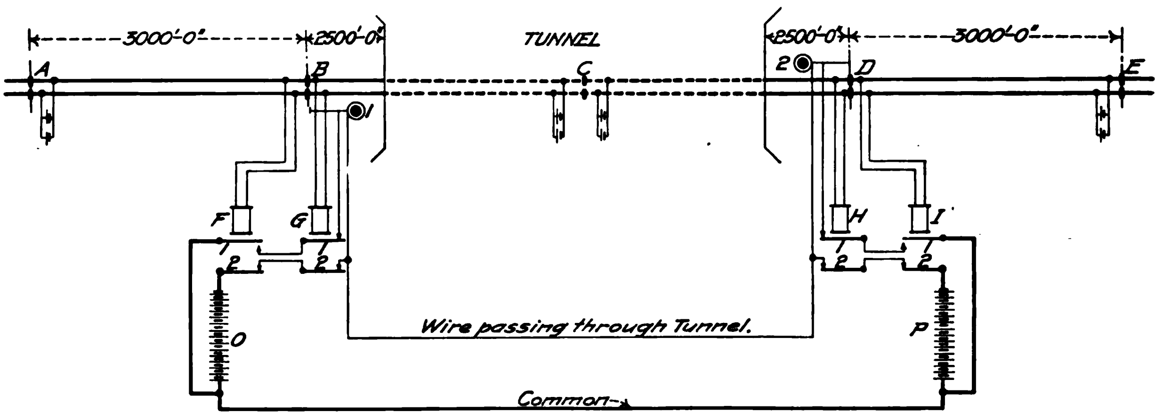


Fig. 395. Arrangement of Circuits for Normal Danger Signals on Single Track for Tunnel Protection. New York Central & Hudson River.

Fig. 395 shows a normal danger system for single track in a tunnel. Signal 1 controls from B to E. Signal 2 from D to A. Signal 1 clears through back point of relay F; signal 2 through back point of relay I. Circuit for signal 1 is from battery P through front contact 2 of relay I, front contact 2 of relay H, wire through tunnel, signal 1, front contact 1 of relay G, back contact 1 of relay F, to common, and back to battery. The circuit for Signal 2 is exactly similar. The wire passing through the tunnel is of small size, so as to be easily broken by the patrolman in case of emergency, thereby holding both signals at the stop position.

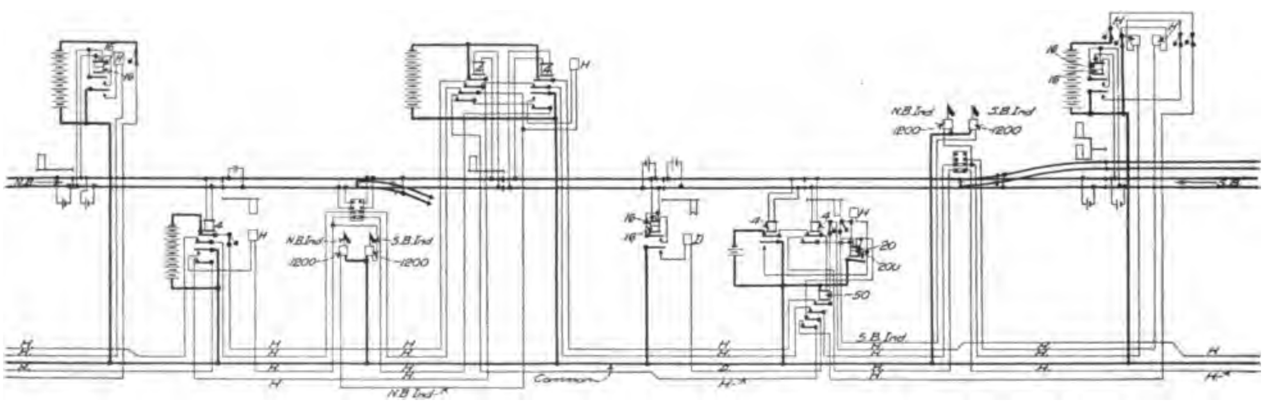


Fig. 396. Circuits for Normal Danger Automatic Signals on Single Track, with Double Switch Indicators. Hall Signal Company.

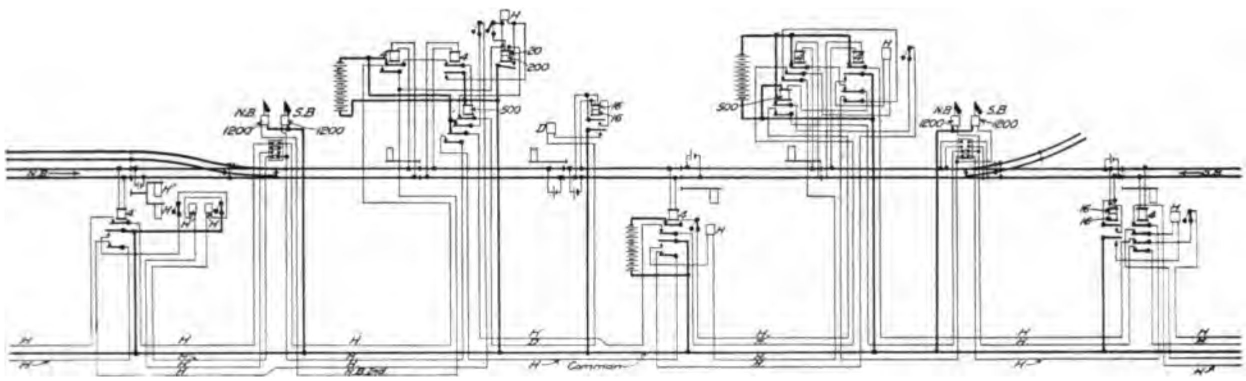


Fig. 397. Circuits for Normal Danger Automatic Signals on Single Track, with Double Switch Indicators.

NOTE.- Fig. 397 is a continuation of Fig. 396.

Figs. 396-397 show a single track normal danger system with two indicators at each switch, one for each direction. Signals are cleared through back points of the track relay in the section in its rear and the control is overlapped in the usual manner. Control circuits are also broken through circuit breaker on first overlap opposing signal in most cases, so that should one of the signals stand clear, the opposing overlap signal could not be cleared. Separate signals are provided for exit from the siding. Indicators in each direction are controlled in parallel with signal governing the block in which they occur but in opposite direction. "16-16" relays are used in some cases to avoid extending clearing wire to the other end of the track section. Home signals having a distant are controlled through a compound line relay. A train approaching the distant signal closes the back contact of the track relay in the section in the rear (in this case a 16-16 ohm clearing relay), thereby completing a circuit from common through the distant clutch to line, front contact of repeating relay governed by track relays in advance, 200-ohm winding of compound relay, front contact of track relays in advance of home signal, through line facing switch box and circuit controller on opposing signal to battery at end of overlap section. This permits sufficient current to flow to energize the compound relay, closing the circuit from common through to front contact, home clutch to the home control wire. This clears the home signal and closes the circuit breaker so that the 20 and 200-ohm windings of compound relay are in parallel, thus reducing the resistance of the circuit sufficiently to permit the distant signal to clear.

Fig. 398 shows the same circuits as Figs. 396-397, except that there is but one turnout.

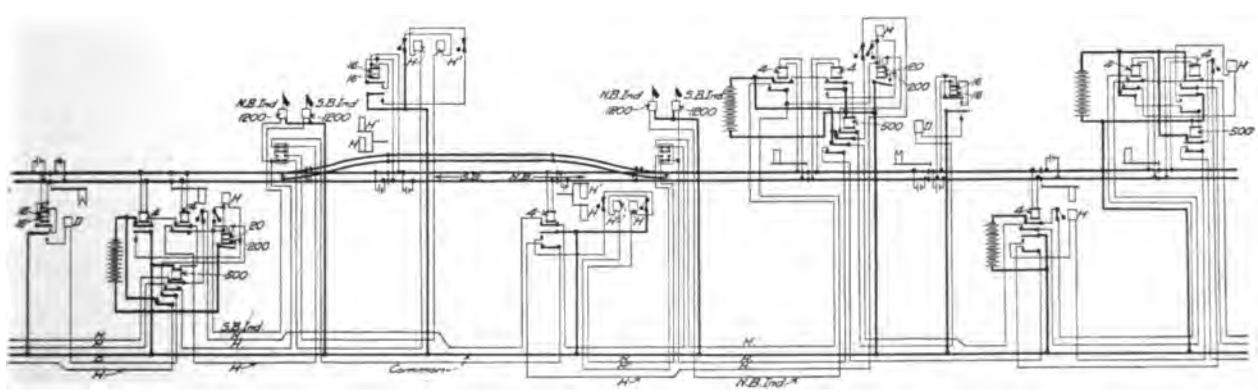


Fig. 398. Circuits for Normal Danger Automatic Signals on Single Track, with Two Indicators at Each Switch.

Fig. 399. The Clockwork Signal Mechanism. The Union Switch & Signal Company.

Fig. 399 shows the mechanism of the clockwork disk signal made by the Union Switch & Signal Company. The power is furnished by a weight shown in Fig. 400, which is wound by hand at intervals. If the weight is allowed to run down the signal takes the stop position. The vertical axis of the signal is connected by miter gears with a horizontal shaft having a ratchet wheel and a winding drum, which are turned by the operating weight. The horizontal shaft carries on one end a cross-head, which has in its arms four pins so placed as to engage indirectly with a detent on the end of a horizontal bar pivoted somewhat to the right of its center and having a slight motion up and down, at right angles to the axis of the cross-head. The horizontal bar is attached at one end to the armature of an electro-magnet and at the other end engages one or another of the detent-toes which in turn engage the pins on the cross-head, according as it is in one or the other of its positions. The place of

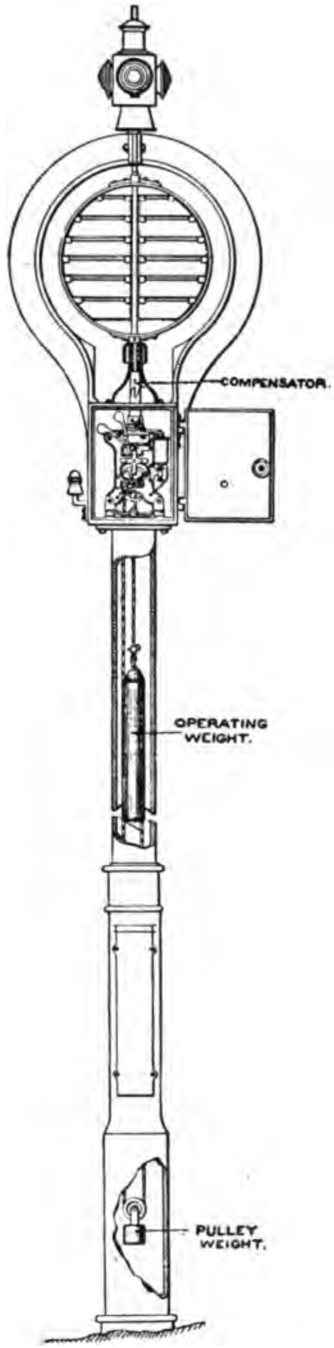
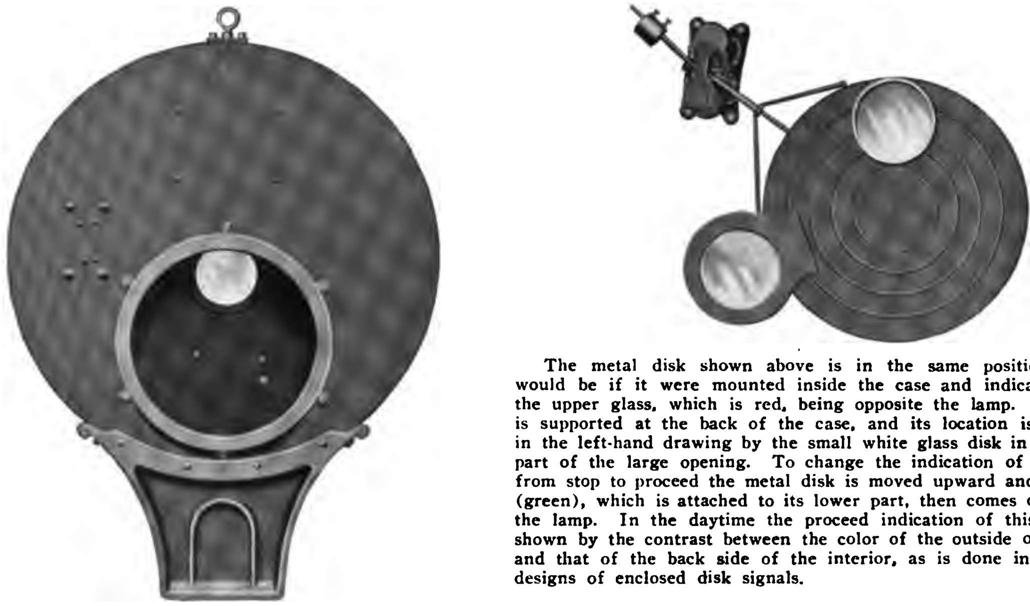


Fig. 400. The Clockwork Disk Signal.

Fig. 401. Enclosed Disk Signal. The Union Switch & Signal Company.



The metal disk shown above is in the same position that it would be if it were mounted inside the case and indicating stop; the upper glass, which is red, being opposite the lamp. The lamp is supported at the back of the case, and its location is indicated in the left-hand drawing by the small white glass disk in the upper part of the large opening. To change the indication of the signal from stop to proceed the metal disk is moved upward and the glass (green), which is attached to its lower part, then comes opposite to the lamp. In the daytime the proceed indication of this signal is shown by the contrast between the color of the outside of the case and that of the back side of the interior, as is done in the older designs of enclosed disk signals.

Fig. 402. Enclosed Disk Signal; Two Colored Night Indications. The Union Switch & Signal Company.

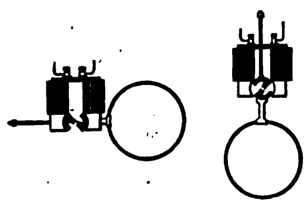


Fig. 403. Disk Signal Mechanism. Hall Signal Company.

Fig. 404. Disk Signals on the Philadelphia & Reading. Hall Signal Company.

the pins is so chosen with reference to the detent on the horizontal bar that when the armature at its rear end is attracted and the bar is at its highest point, the disk will be held in the position indicating "clear," but if the current ceases in the electro-magnet, its armature is drawn away (the other end of the bar being heavier), and the detent releases the cross-head, which then turns one-quarter of a revolution, carrying the signal to the "stop" position. It is arrested by the detent engaging with the next pin on the cross-head. When the electro-magnet is again energized the clock work rotates the cross-head another quarter revolution and brings the signal again to "clear." The current through the electro-magnet in the signal is controlled by the track circuit relays, as shown in Fig. 373, and these are open or closed, according as the block is occupied or unoccupied by a train.

The outward appearance of a Hall disk signal is shown in Fig. 404. The case is made with wooden front and back and sheet iron sides and top, and is supported on a post of suitable height, or on a bridge, and usually is painted a dark color. The disk, about 18 inches in diameter, made of silk or other light fabric, stretched on a metal ring, or of aluminum, very thin, is fixed to the armature of an electro-magnet in the manner shown in Figs. 403, 405, 406, 407. When the signal magnet is energized the armature holds the disk up, in the position shown at the left of Fig. 403; and an approaching engineman, looking at the glass-covered opening, sees the back of the interior of the case, which is of ground glass, white; this is the clear signal. On the withdrawal of the electric current the disk drops by gravity to a position before the window (the armature and rod turning on the axis as shown), thus displaying a red, or stop, signal.

The enclosed disk is usually mounted on the top of a post or pillar, as before stated. When home and distant signals are used, the cases are arranged as shown in Fig. 404. The upper signal has a red disk, and is the home signal, while the lower one has a green or yellow disk, and is the distant signal for the block section next beyond. Fig. 406 illustrates the Hall disk mechanism with "hold clear" attachment. This consists of an additional set of magnets of high resistance, as shown. The Z rotary armature carries on an arm a second flat armature for the "hold clear" coils. A circuit breaker controls the circuits for the two sets of coils so that when the signal is at stop they are in parallel; when at clear, they are in series. Thus the signal is held clear on a low current consumption. Fig. 407 shows the Hall disk instrument used by the Chicago & North-Western. This has two separate night indications. The magnet has only one coil instead of two.

The Union Switch & Signal Company's disk signal is shown in Figs. 401-402. In this design the case is of metal (pressed steel). It is made very narrow, leaving room enough only for the disk, and the electro-magnet is contained in a box outside the main case. The joints of the case are caulked, making it airtight, so that the disk cannot be affected by moisture. The box containing the magnet is also tight, but can be unlocked by the repairman. The front and rear glasses are of heavy plate fixed in brass rings. The lamp

Fig. 405. Enclosed Disk Signal Mechanism. Hall Signal Co.

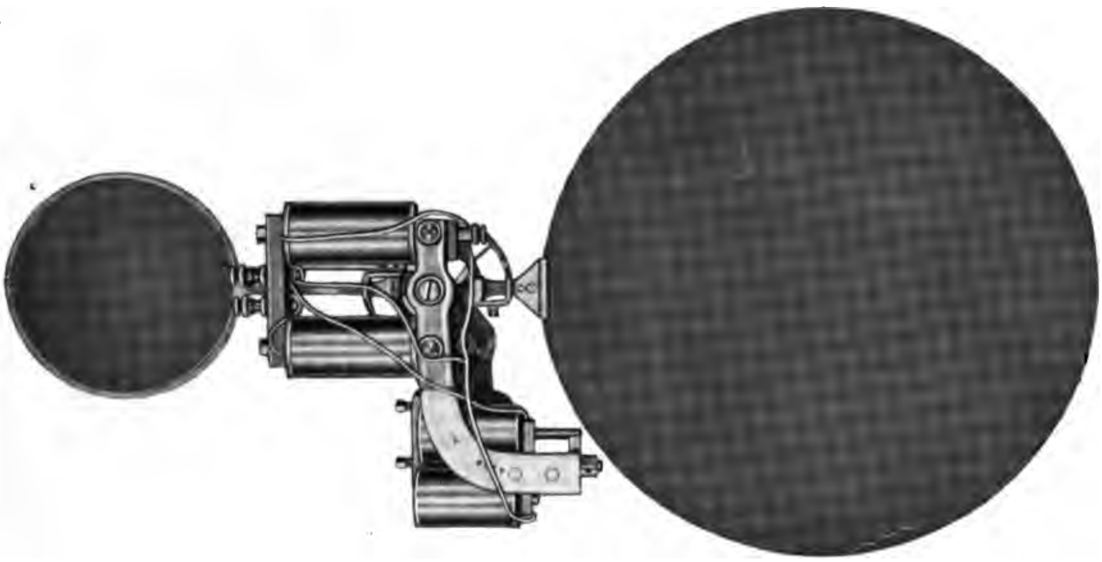
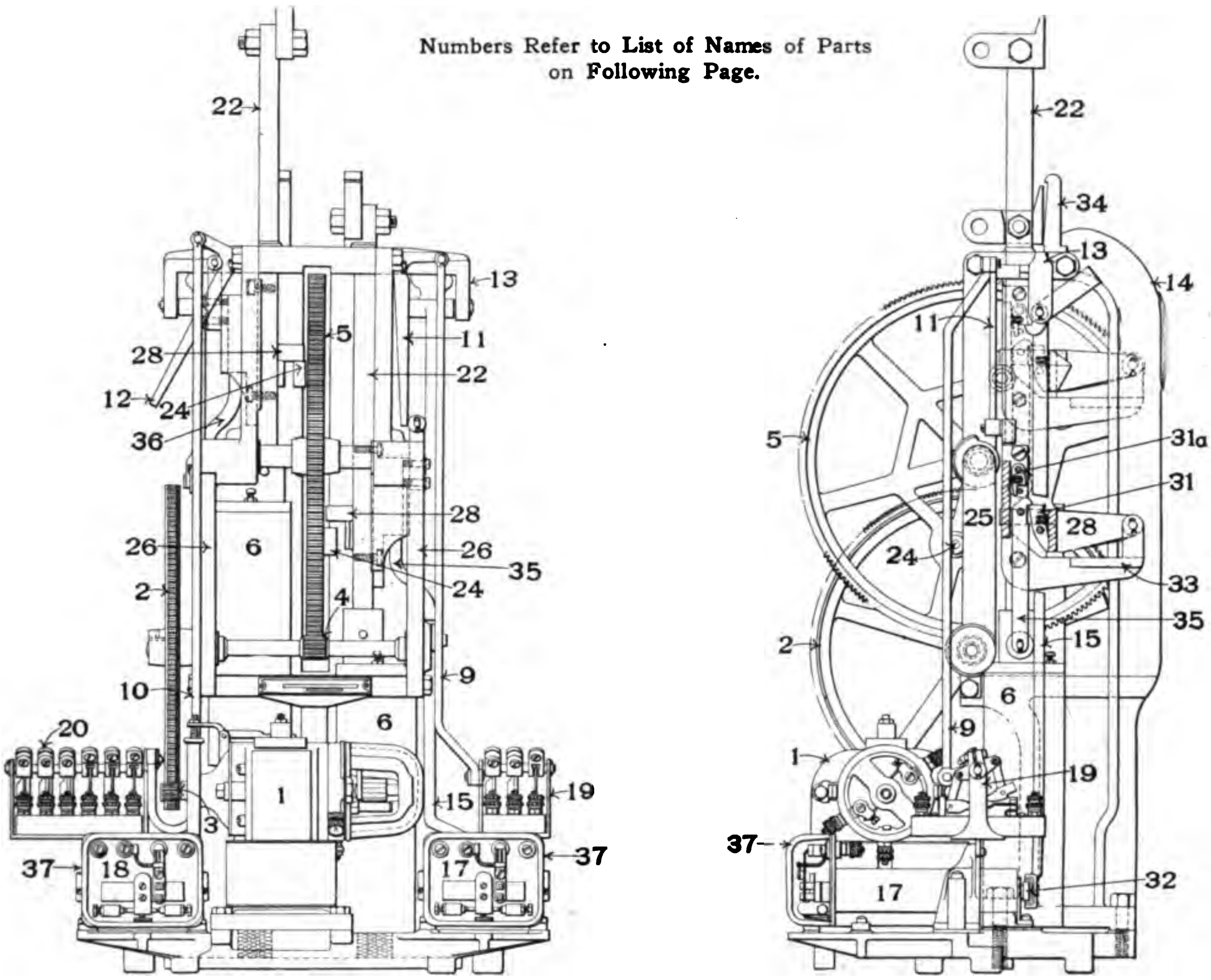


Fig. 406. Hall Enclosed Disk Signal Mechanism, with Hold-Clear Attachment.

Fig. 407. Hall Enclosed Disk Signal Mechanism; Two Colored Night Indication. Chicago & North-Western.

Numbers Refer to **List of Names** of Parts on **Following Page.**



Figs. 408-409. Style "F" Electric Motor Signal Mechanism. Hall Signal Company.

is supported on hinges, so that it can be turned around to be cleaned and filled. The whole case and the parts supported by it are very light, important parts being made of aluminum, and it may be revolved on its bearings.

In the Union Switch & Signal Company's style of signal (Fig. 401) the night signal is a lamp fixed at the back of the disk, outside the case, showing uncolored for clear and illuminating the glass set into the disk for the opposite indication. In the Hall signal the lamp is placed behind the smaller opening near the top of the case, and the upper end of the rod which carries the main disk has fixed to it a small transparent disk, colored to correspond to the color of the day disk (Figs. 405-407).

Fig. 402 shows how the Union disk signal may be made to give two distinct night indications. The glass set into the disk is the stop or caution color; the one projecting from the disk is the clear color.

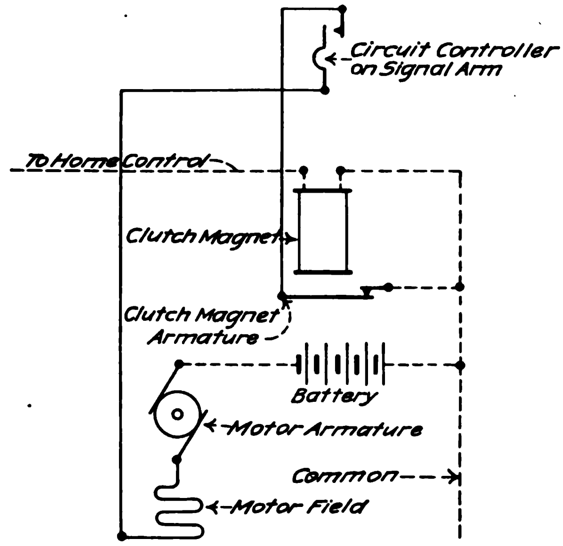


Fig. 410. Local Wiring for Single Arm Style "F" Electric Motor Signal Mechanism.

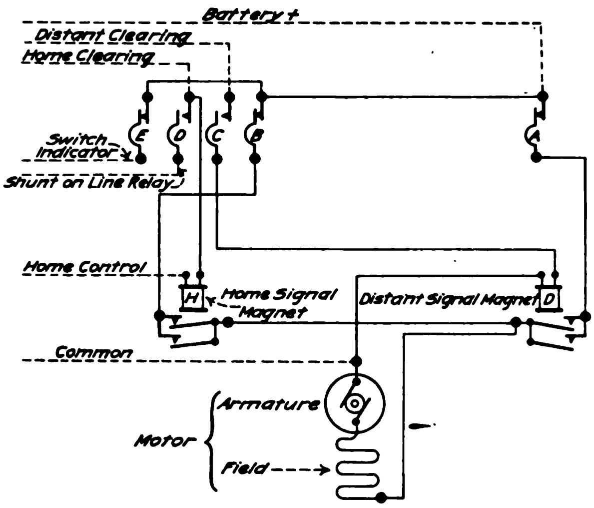
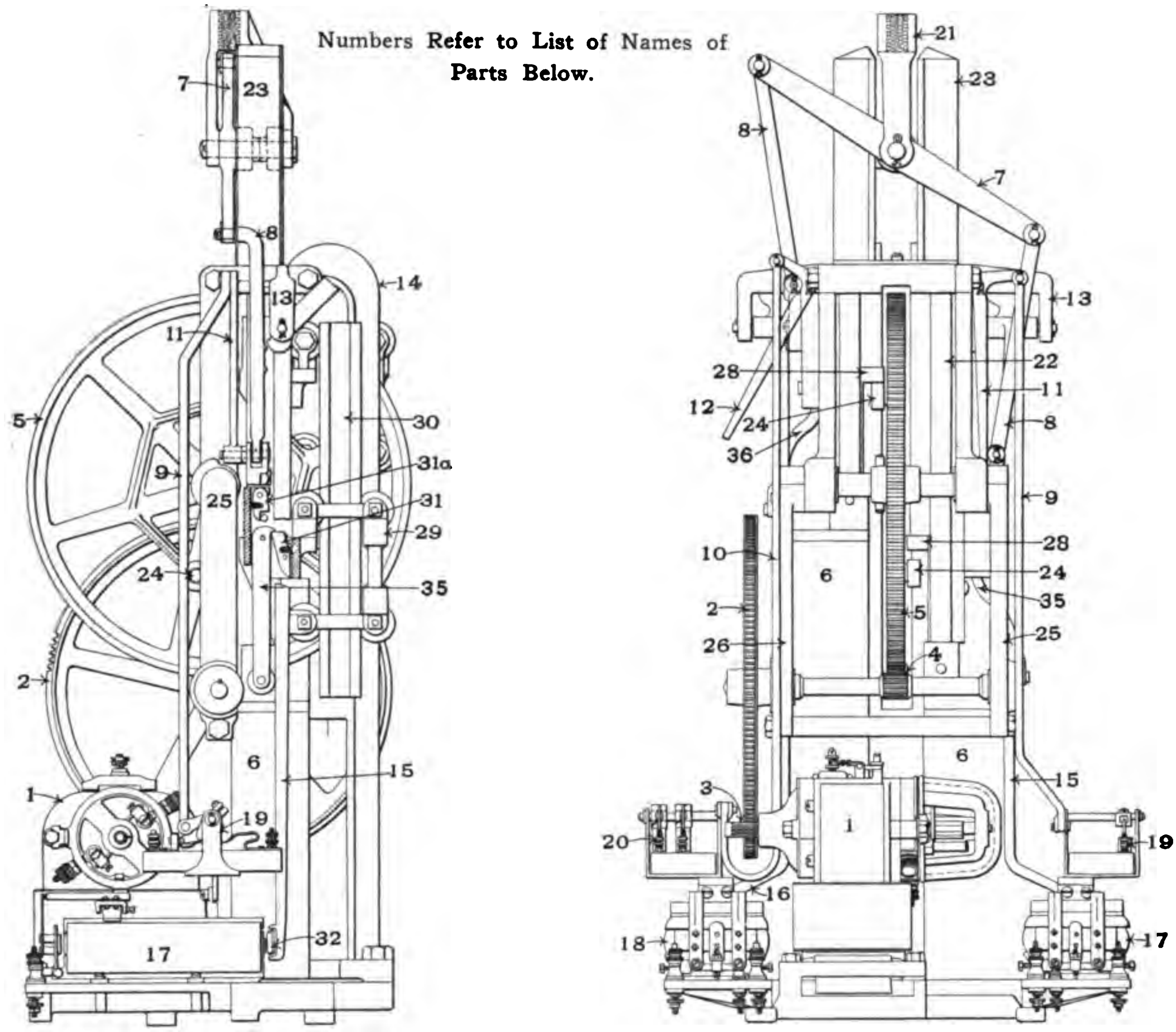


Fig. 411. Local Wiring for Two-Arm Style "F" Electric Motor Signal Mechanism.

Figs. 410-411 show circuits for wiring the mechanism of a one and two-arm Style "F" Hall motor signal. The full lines represent wiring furnished with the mechanism, the dotted lines the wiring which must be done after the signal has been installed. Fig. 411 is used when this signal is in the normal danger system (see Figs. 390-392); Fig. 410 may also be used when this style of signal is used as a power operated signal at an interlocking plant.



Figs. 412-413. Style "F" Electric Motor Signal Mechanism, Equipped for Three-Position Signal. Hall Signal Company.

Names of Parts of Hall Electric Motor Signals. Figs. 409, 412, 413.

Two-Arm and Three-Position.

1 *Motor*
2 *Gear Wheel*
3 *Motor Pinion*
4 *Shaft Pinion*
5 *Driving Gear*
6 *Dash Pot*
7 *Rocking Beam*
8 *Rocking Beam Operating Rods*
9 *Circuit Closer Rod R. H.*
10 *Circuit Closer Rod L. H.*
11 *Escapement Crank R. H.*
12 *Escapement Crank L. H.*
13 *Clutch Lever Shaft Bearing*
14 *Frame*
15 *Clutch Lever R. H.*
16 *Clutch Lever L. H.*
17 *Clutch Magnets R. H.*
18 *Clutch Magnets L. H.*
19 *Circuit Closer R. H.*
20 *Circuit Closer L. H.*
21 *Screw Jaw*
22 *Thrust Rod*
23 *Thrust Rod Cover*
24 *Lifting Roller*
25 *Side Frame R. H.*
26 *Side Frame L. H.*
28 *Thrust Piece L. H.*
29 *Thrust Piece Carriage*
30 *Carriage Guide*
31 *Latch*
31a *Hold Clear Latch*
32 *Clutch Armature*
33 *Latch Support*
34 *Safety Latch*
35 *R. H. Clearing Lever*
36 *L. H. Clearing Lever*
37 *Glass Contact Cover*

Letters Refer to List of Names of Parts on Following Page.

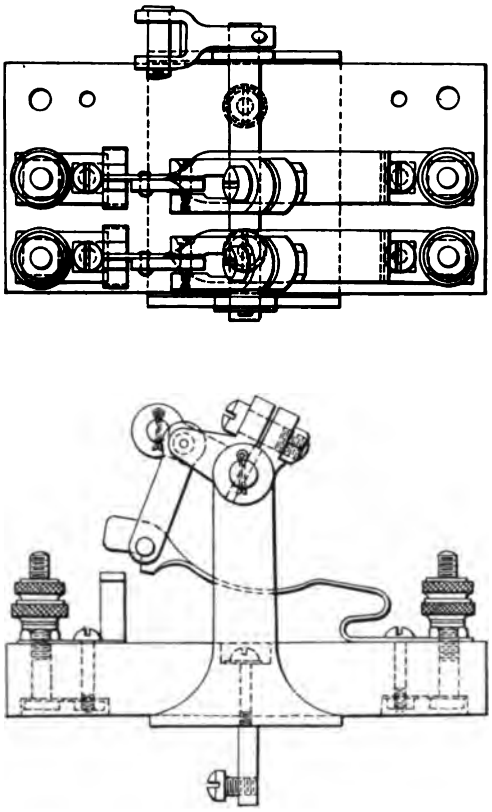


Fig. 414. Circuit Controller for Automatic Signals. Hall Signal Company.

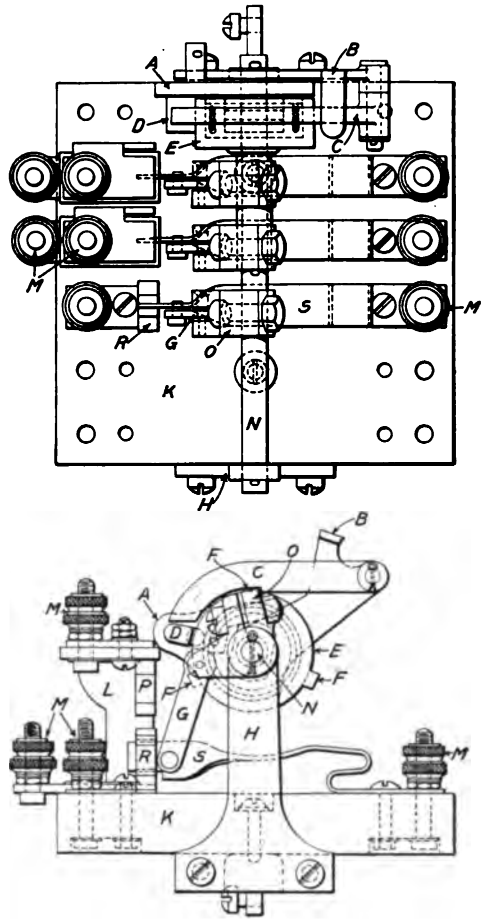


Fig. 416. Pole Changer for Automatic Signals.

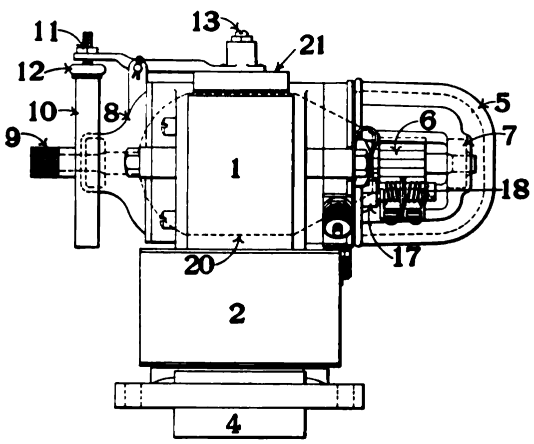


Fig. 417.

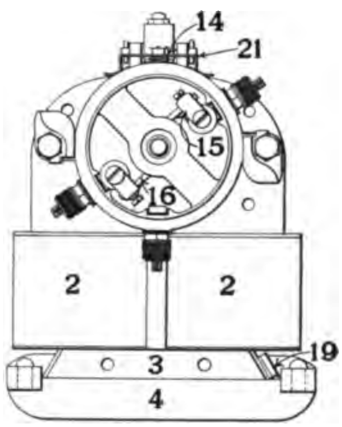


Fig. 418.

Electric Motor for Style "F" Mechanism.

Names of Parts of Electric Motor for Style "F" Mechanism. Figs. 417-418.

1	*Laminated Field Cores*	**8**	*Bearing Support, Back*	**15**	*Brush Holder*
2	*Field Coils*	**9**	*Pinion*	**16**	*Brush*
3	*Laminated Yoke*	**10**	*Brake Wheel*	**17**	*Brush Holder Support*
4	*Base*	**11**	*Brake Adjusting Screw*	**18**	*Brush Holder Tension Spring*
5	*Glass Commutator Shield*	**12**	*Brake Shoe*	**19**	*Wedge*
6	*Commutator*	**13**	*Brake Armature Screw*	**20**	*Armature*
7	*Bearing Support, Front*	**14**	*Brake Armature Spring*	**21**	*Brake Armature*

ELECTRIC MOTOR SIGNAL MECHANISMS.

HALL SIGNAL COMPANY

Figs. 408-409 illustrate the Hall Signal Company's style "F" two-arm motor signal mechanism. In the illustrations the left half of the mechanism is shown in the clear position and the right half in the stop position. One-arm mechanisms are exactly like two-arm mechanisms, except that one set of clutch magnets, one thrust rod, thrust piece, clutch lever, etc., are omitted. The cast-iron base supports the motor, clutch coils, pistons of the dash-pot and the frame 14. This frame supports the clutch lever 15. The steel thrust rod 22 is rigidly pinned to the cylinder of the dash-pot 6. The base has two pedestals rigidly attached to support the pistons for the dash-pots. The piston, in conjunction with the cylinder, forms the guide for the lower end of thrust rod 22. The upper end of this rod runs in a babbitted bearing in the frame. Secured to the thrust rod is the latch support 33, which carries the clearing lever 35, the thrust piece 28 and the latch which engages the lug on the clutch lever 15 to hold the signal clear. The thrust piece carries the latch 31, which engages the lug on clearing lever 35. The large gear wheels are phosphor bronze. They are driven by the steel pinion 3 on the motor and the pinion and shaft 4. The phosphor bronze knife blade contacts of the circuit controller 19 (see Figs. 414-416) are operated by the circuit controlling rod 9 attached to the escapement crank 11. The escapement crank is controlled by the roller attached to the latch support 33. The front armature of the clutch magnets controls the multiple contacts for the motor circuit. The back armature is attached to the clutch lever 15, which enables the magnets to control the clutch lever. 20 is a multiple circuit controller (Figs. 414-416) operated in the same manner as 19. Glass cases 37 cover the armature and contacts of the clutch magnets 17 and 18 to exclude dust. 12 performs the same function as 11, but is left-handed. 10 corresponds in the same way to 9. 33 slides in guides in the frame. 26 is a part of the main frame which carries the bearings for the two gear wheels, 2 and 5. In Figs. 412-413 is shown the guide 30 for the carriage 29 which carries 33. The motor 1 (see Figs. 417-418) is series wound. The fields are laminated iron with but one joint, which is dovetailed, making them further continuous and reducing the magnetic loss on account of joints to a minimum. The armature and commutator are completely enclosed by a brass case over the armature and a glass case over the commutator. The glass case is held in position by two springs bearing on two lugs on the glass. The shaft runs in self-oiling ball bearings.

When the home signal is at stop the circuit controller contacts for the motor are closed and the contacts controlling the distant clutch magnets are opened so that it is impossible for the distant signal to clear until after the home signal has cleared. When the home signal clutch magnet is energized it closes the motor circuit to the contacts on the front armature 17 and at the same time holds the back armature 32, which prevents the clutch lever from moving when pressure is applied to clear the signal. The home circuit being closed, the motor revolves the gears and brings the stud roller 24 under the thrust piece 28 and pushes it up. Since the clutch lever 15 is held by this armature, it prevents the clearing lever 35 from swinging back and by means of the lug on this lever engaging the latch 31 in the thrust piece 28, carries the thrust rod and all the parts attached to the clear position. In moving to the clear position the roller pivoted on the lower end of clearing lever 35 rolls along the front edge of clutch lever 15. In the last one-eighth inch movement of the signal to the clear position the roller attached to the latch support 33 strikes the front lever of the escapement crank 11 and moves it on its pivot, and by means of the rod 24 operates the circuit controller. This opens the motor circuit and closes a contact in the distant signal circuit. The signal is held in the clear position by the lug on the clutch lever 15, engaging under a latch on latch support 33. This leaves the gears free to continue their movement, as soon as the distant clutch magnet is energized to clear the distant signal. After the signal has been cleared the stud roller 24 moves from under the thrust piece 28. When the signal circuit is broken the clutch magnet is de-energized. The front armature opens the motor contacts to keep the motor circuit open and the back armature being released permits the clutch lever 15 to swing back far enough for the holding latch in the latch support 33 to pass the lug on the clutch lever and allow the signal to go to stop by gravity. The movement of the signal to stop is cushioned by the dash-pot 6. The circuit controllers are reversed as soon as the signal begins to go to the stop position. If by any chance the motor circuit should be closed without the clutch magnets being energized, the motor would simply revolve the gears, and when the stud roller engaged the thrust piece it would raise it without affecting the signal, as the clearing lever 35 would be free to swing back and permit the latch 31 to pass it. When the stud roller passed from under the thrust piece it would drop back in place and be ready to clear the signal when the clutch magnet energized. Or if the clutch magnet should become de-energized when the signal was partly cleared, the clearing lever 35 would be permitted to swing back on account of clutch armature being released, and allow the latch 31 to pass the lug from the clearing lever, the signal would go to stop, the thrust piece 28 would remain on top of the stud roller by swinging on its pivot, and when the stud roller moved from under it, it would drop back in its place ready for another operation.

Figs. 412-413 show front and side elevation of a three-position Style "F" motor mechanism. This is identical in construction with the mechanism shown in Figs. 408-409, except for the addition of several parts. (Numbering of parts is the same as in Figs. 408-409.) Two guides, 23, for the thrust piece, 22, are mounted on top of the frame. These act also as guides for the jaw, 27, which is attached to the up-and-down rod. 21 carries the rocking beam, 7, each end of which is attached to one of the thrust rods, 22, by means of link 8. Thus, raising one-half of the mechanism as shown puts the signal to the 45° or caution position. Raising both parts clears the signal. No glass covers are shown on 17 and 18.

A view of the Hall Signal Company's circuit controller (19 and 20, Figs. 408-409-412-413. 15, Fig. 448) is shown in Fig. 414. It consists of a porcelain base to which a bronze frame is secured. The base also supports the spring knife switches, the contacts and the binding posts. The frame acts as a bearing for a shaft and also as a means of attachment to the mechanism. The shaft carries one or more clamped arms to which are secured links made of fiber. To the lower end of these links the spring knife contacts are fastened.

The pole changer made by the Hall Signal Company is shown in Fig. 416. K is a porcelain block. H is the brass frame carrying the shafts, N, and serving as a means of attachment to the signal mechanism. L is a bronze support for the upper contacts, P, and binding posts. All binding posts, M, are similar. Clamp arms, O, are fastened to the shaft and carry insulating links G. These links actuate the knife blades, S. Lower contacts, R, are similar to upper contacts, P. Attached to the shaft, N, is a drum, E, within which there is a spiral spring, one end fastened to the drum, the other to disk A. A moves loosely on N and carries a pin to which the operating rod is fastened. Suppose A to be revolved to the right. Motion would be imparted to E through the spring, but one of the lugs, F, would catch in the notch of pawl C, which is pivoted to the frame. This would prevent E and N from revolving so that further motion of A would compress the spring. When A reaches a point where lug D strikes pawl C and raises it, the spring will cause E and N to snap over and carry the knives S to the upper contacts P. C is prevented from flying too far by stop B. When A is revolved to the left, lug D strikes a second lug F on E and thereby moves knives S to the lower contacts by means of N and G.

Names of Parts of Hall Pole Changer. Fig. 416.

A	*Disk Carrying Operating Pin*	**F**	*Lugs on E*	**M**	*Binding Posts*
B	*End Bearing of Frame with Stop*	**G**	*Insulating Link*	**N**	*Shaft*
C	*Pawl.*	**H**	*End Bearing of Frame*	**O**	*Clamp Arm*
D	*Lug on A*	**K**	*Porcelain Base*	**P**	*Upper Contact*
E	*Spring Case or Drum*	**L**	*Bracket*	**R**	*Lower Contact*

Fig. 419. Style "B" Electric Motor Signal Mechanism; Home Slot in Clear Position; Distant Slot at Caution. The Union Switch & Signal Company.

Fig. 420 shows the arrangement of local wiring for the two-arm Style "B" mechanism (Figs. 419, 421, 424 and 427) when used with the polarized track circuit, as shown in Fig. 377.

The slow release on the home slot magnet is accomplished by means of a copper sleeve over the core of the magnet inside the coil. This acts as a short-circuited winding of large current capacity which induces sufficient magnetism in the core to keep it energized a short time after the current has been cut off from the coils on account of the current induced in it when the holding circuit is broken. The object of this arrangement is to hold the home arm clear while the track relay is momentarily de-energized by the reversal of the track circuit. This slow acting feature is required only in the polarized system.

The back contact on the neutral armature of the relay also assists in the slow release of the home slot, by closing a local circuit, without battery, through it when the relay is de-energized, thereby allowing self-induced current to flow through the slot coil.

The compound winding on the distant slot magnet is provided to economize in the use of current. The motor circuit passes through the low resistance winding and is opened when the distant arm reaches the clear position. The slot then holds the arm clear by current in the 2,000-ohm coil only.

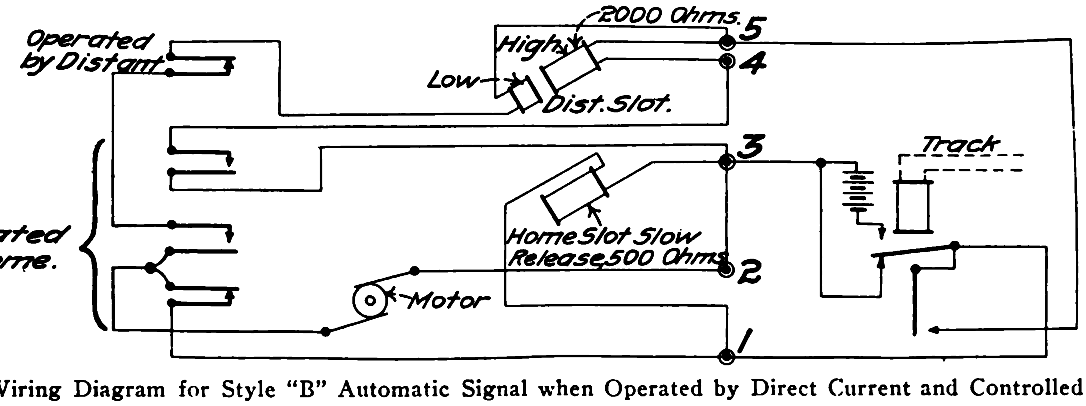


Fig. 420. Wiring Diagram for Style "B" Automatic Signal when Operated by Direct Current and Controlled by Polarized Relay.

Letters and Numbers Refer to List of Names of Parts on Page with Fig. 428.

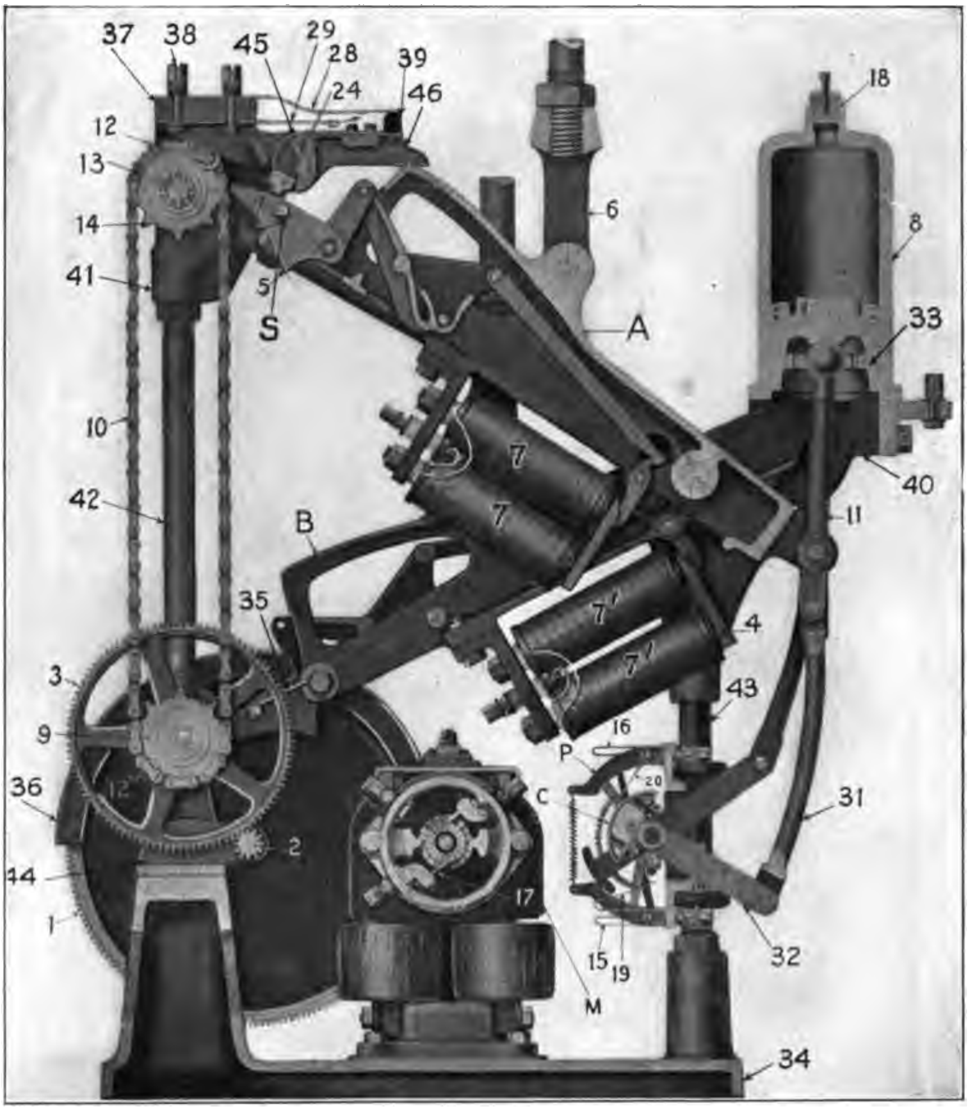


Fig. 421. Sectional View, Style "B," Motor Mechanism. Union Switch & Signal Company.

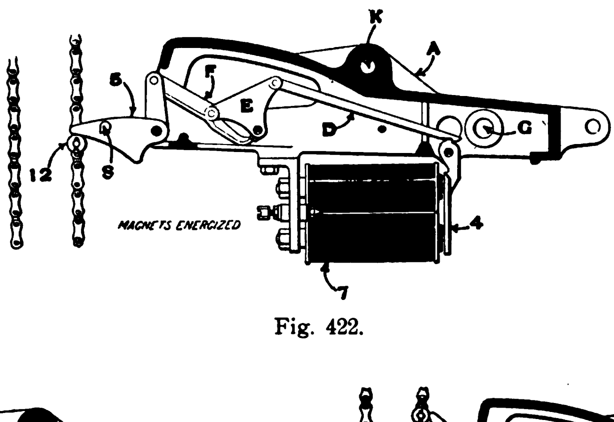


Fig. 422.

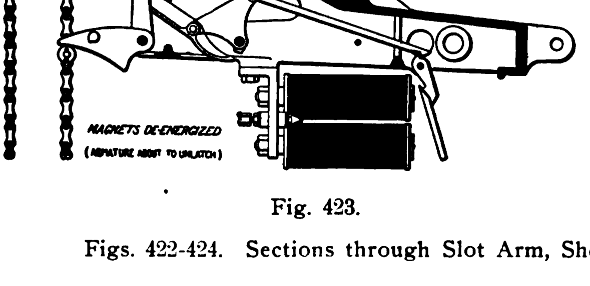


Fig. 423.

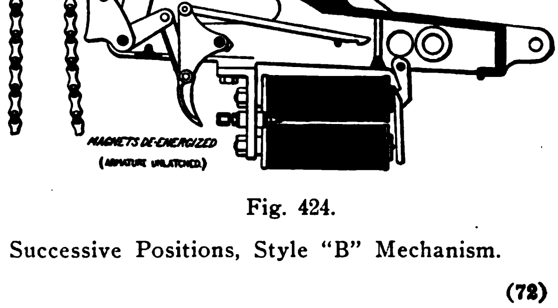


Fig. 424.

Figs. 422-424. Sections through Slot Arm, Showing Successive Positions, Style "B" Mechanism.

MOTOR SIGNAL MECHANISM

THE UNION SWITCH & SIGNAL COMPANY

The two-arm motor signal mechanism made by the Union Switch & Signal Company is shown in Fig. 419. Fig. 421 shows the same mechanism partly in section. The operation of the slot-arm is shown in Figs. 422-424. When the signal is in the stop position and current is supplied to clear it the operation is as follows: (For circuit see Fig. 420.) Current passes from relay to home slot coil 7 and motor M (see Fig. 428) in multiple. The motor revolves the gear 3 by means of the large gear 1 and pinion 2. This causes the trunnion 12 on chain 10 to engage the prongs of the fork head 5, and move the slot-arm through an arc about G as a center. This clears the signal which is operated by an up and down rod attached at K by jaw 6. When the slot-arm has reached the position shown at A, Fig. 421, the lugs S, on the fork head 5 engage hooks on the pawl 24 (shown dotted in Fig. 421). This supports the arm in the clear position. In assuming this position the top of slot-arm strikes against the lever 46. This causes the insulated block 39 to raise contact spring 28 off of contact spring 29, thereby opening the motor circuit and stopping the motor. It also closes the circuit for the distant signal (Fig. 420). In order that pawl 24 shall be certain to engage lugs S, a spring, 45, is fastened to lever 46. Its lower end bears on pawl 24, therefore, the raising of lever 46 by the slot-arm puts tension on the spring and forces pawl 24 into engagement with the lugs S. When the slot magnet is de-energized the armature 4 falls away by gravity. This releases latch D, permitting link F and fork head 5 to assume the positions shown in Fig. 424. This allows the signal to go to the stop position. A dashpot 8 provides an air cushion to absorb shocks. Fork head spring 35 restores the fork head to its normal position after the slot-arm has passed the trunnion or pawl when returning to the stop position. One feature of this signal is the arrangement of parts whereby the slot armature 4 moves both to and away from the pole pieces by gravity. The distant slot 7' clears the distant signal in exactly the same way as the home was cleared, except that it has two windings, one high and one low (see Fig. 420). Connecting link 31 is used to actuate a pole-changer P or circuit controller C for the control of outside circuits. Single arm mechanisms are furnished with only one slot-arm, sprocket, chain, and dashpot. Fig. 425 is a view of the gear and sprocket wheels with their bearings and chains. This constitutes the running gear of the mechanism.

Fig. 426 is a wiring diagram used in place of that shown in Fig. 424 when the signal is to be operated by alternating current.

Fig. 427 shows the double arm mechanism (Figs. 419-421) equipped to operate a single arm 3-position signal. The up and down rod terminates in a jaw carrying a pinion. This pinion engages on each side with a rack operated by each slot-arm. The pinion and two racks are enclosed in a case clamped to the frame tubing. Thus, when one slot-arm is raised its rack revolves the pinion which travels upward on the other rack. This puts the signal in the intermediate position. Raising of the second slot-arm causes the pinion to travel up the first rack and completes the stroke of the signal.

The direct current motor (Fig. 428) is series-wound and is usually designed to work on 12 volts. Its brake is controlled by the field magnet, and its commutator is protected by a glass shield, as shown.

Fig. 425. Running Gear and Shield, Style "B" Motor Signal. The Union Switch & Signal Company.

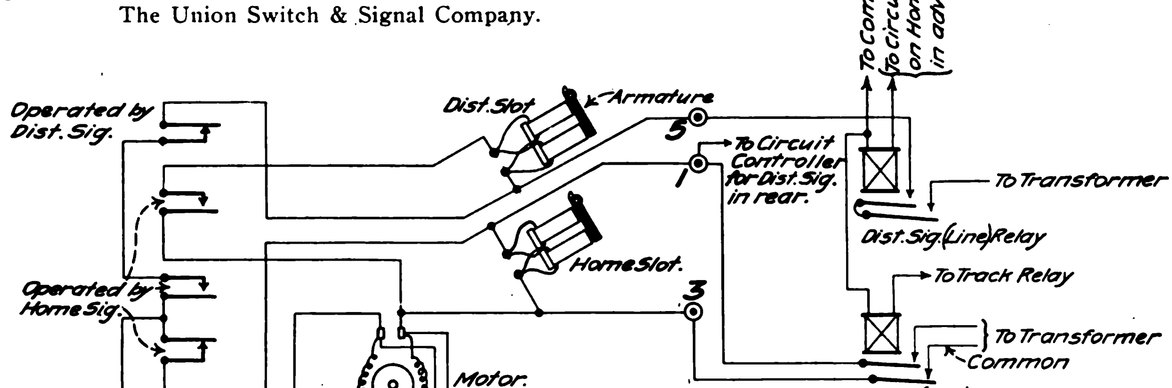


Fig. 426. Wiring Diagram for Style "B" Automatic Signal when Operated by Alternating Current. See Figs. 548-549.

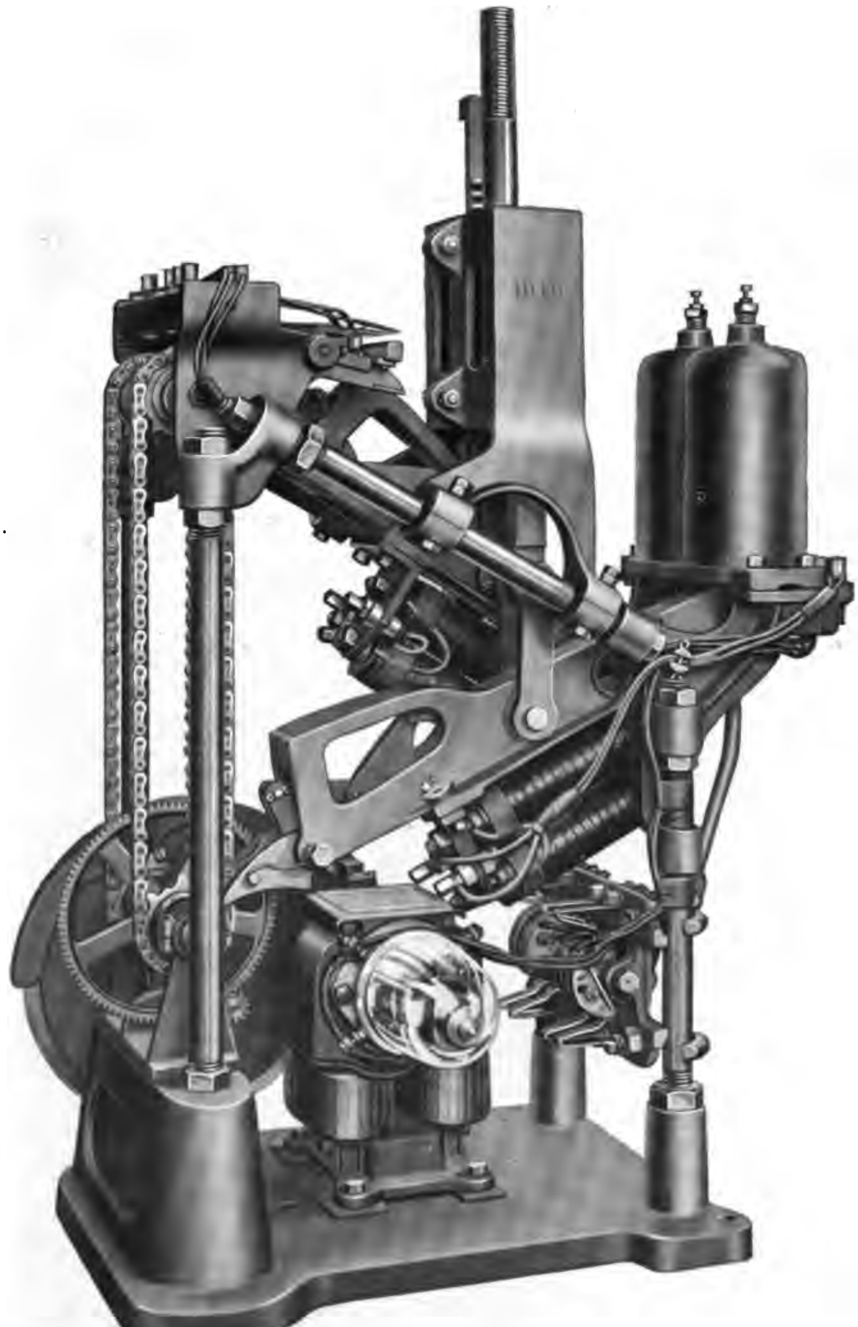


Fig. 427. Style "B" Mechanism Equipped for Three-Position Signal. The Union Switch & Signal Company.

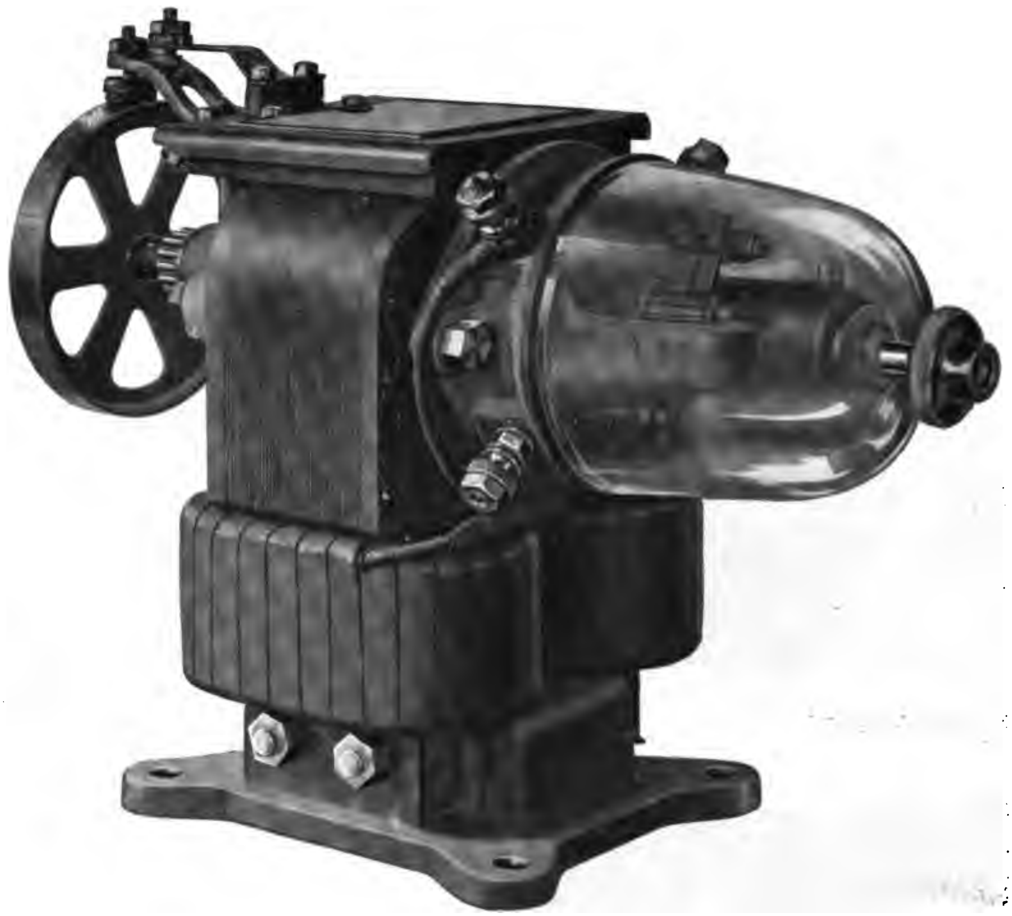


Fig. 428. Electric Motor for Style "B" Automatic Signal. The Union Switch & Signal Company.

Names of Parts, Union Style "B," Motor Signal Mechanism, Figs. 421-424.

1	*Main Gear Wheel*	**32**	*Operating Arm for Pole Changer*
2	*Counter Shaft and Pinion*	**33**	*Piston for Buffer Cylinder*
3	*Intermediate Gear Wheel*	**34**	*Mechanism Base*
4	*Slot Armature*	**35**	*Coil Spring for Forked Head of Slot-Arm*
5	*Forked Head*	**36**	*Main Gear Shield*
6	*Screw Jaw*	**37**	*Slate Base for Contact Springs*
7	*Pair Home Slot Magnets*	**38**	*Binding Post*
7[1]	*Pair Distant Slot Magnets*	**39**	*Insulation for No.* **46**
8	*Buffer Cylinder*	**40**	*Buffer Cylinder Bracket*
9	*Lower Sprocket Wheel*	**41**	*Contact Spring Board Bracket*
10	*Chain*	**42**	*Long Upright for Frame*
11	*Piston Rod for Buffer Cylinder*	**43**	*Short Upright for Frame*
12	*Trunnion*	**44**	*Bearing Bracket*
13	*Upper Sprocket Shaft*	**45**	*Spring for Circuit Closing Lever*
14	*Upper Sprocket Wheel*	**46**	*Circuit Closing Lever*
15	*Lower Contact Spring for Pole Changer*	**A**	*Home Slot-Arm Casting*
16	*Upper Contact Spring for Pole Changer*	**B**	*Distant Slot-Arm Casting*
17	*Motor Brush*	**C**	*Contact Piece for Circuit Controller*
18	*Check Valve for Buffer Cylinder*	**D**	*Latch*
19	*Lower Contact Spring for Circuit Controller*	**E**	*Three Way Crank*
20	*Upper Contact Spring for Circuit Controller*	**F**	*Link with Stop*
24	*Pawl for Supporting Slot-Arm*	**M**	*Motor*
28	*Long Contact Spring*	**P**	*Pole Changer*
29	*Short Contact Spring*	**S**	*Lug on* **5**
31	*Pole Changer Operating Link*		

Fig. 429. Front View, Model 5, Motor Signal. General Railway Signal Company.

Fig. 430. Model 5, Motor Signal Mechanism.

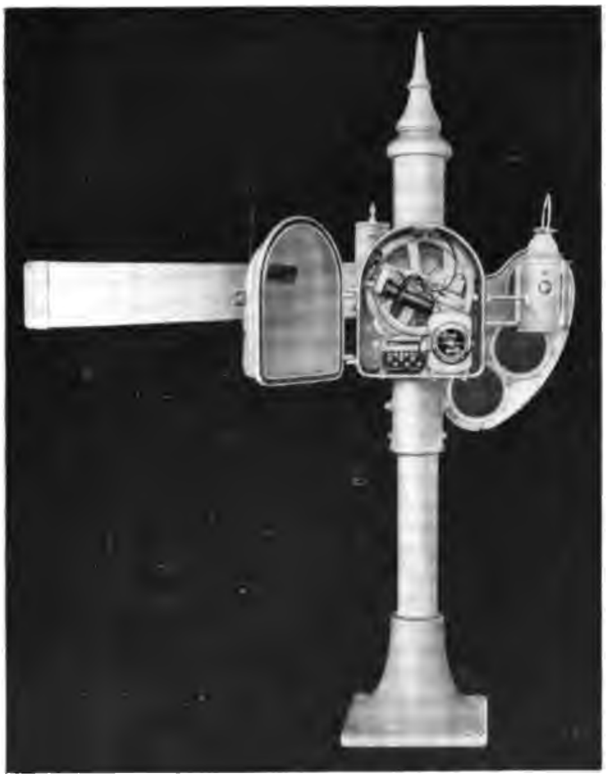


Fig. 431. Rear View, Model 5, Motor Signal.

SPINDLE MECHANISM.

GENERAL RAILWAY SIGNAL COMPANY.

A general view of the Model 5 automatic semaphore, made by the General Railway Signal Company, is shown in Fig. 429. The signal is of the spindle mechanism or top-post type and is mounted upon an ordinary iron post. There are no outside connections, as the mechanism is all contained in the signal case. The signal shown is of the lower-quadrant two-position, 60° type, but is made so that it can be used for both upward and downward inclination and for two or three position, as desired. A rear view of the signal with door open, giving an idea of the arrangement of the signal mechanism assembled in the case, is shown in Fig. 431. The case is weatherproof. The wires for the control of the signal are enclosed in the post and connect with the signal mechanism at the terminal board in the upper part of the case.

The signal mechanism assembled outside of the signal case is shown in Fig. 430. The slot mechanism shown within the rim of the large gear is mounted upon the spindle to which the spectacle is directly connected and consists essentially of the disk, magnet, working coil, retaining coil, lever dog and connector. The large gear which is actuated by the motor through a chain of intermediate gears has five studs mounted upon it. These studs engage with the slot dog, and when the mechanism revolves carry the signal to the clear position. The circuit controller is operated by the slot arm, which comes in contact with the cam connected to the controller shaft. This provides effective control of all circuits concerned in the operation. A buffer dash-pot is provided to take up the concussion of the spectacle and slot mechanism when returning to the stop or caution position. This is accomplished through a buffer crank directly connected to the spindle which makes contact with the buffer piston when the signal is approaching such position.

In order to provide against improper operation of the signal arm by any outside agency, a lock is provided which securely locks the slot cam and signal arm in the stop position when the circuit is de-energized, as shown in Fig. 432. This lock is actuated by one of the studs mounted upon the main gear when the latter revolves to clear the signal, as the stud comes in contact with the locking dog and unlocks the cam before moving the slot arm.

The method of operation can be more clearly seen by referring to the wiring diagram shown in Fig. 435 and to Figs. 432-434. When the local signal circuit is closed energy flows through the signal operating wire, binding posts 1 and 2, low resistance magnet coil, posts 4 and 3, wire 5, motor cut-out contacts, wire 6, motor fields and armature in series, wire 7 to common. Slot coils are then energized, attracting armature of slot, as shown in Fig. 432. At the same time the motor moves to clear the signal. This is accomplished in the following manner: When the main gear, actuated by the motor through intermediate gears, revolves one of the five studs mounted upon it and adjacent to the unlocking mechanism engages with the normal lock, unlocks the signal and engages the slot dog, carrying the slot mechanism and signal arm to the proceed position, as shown in Fig. 433. The cut-out contact, Fig. 435, is then opened by the circuit breaker actuated by the slot arm coming in contact with the cam connected thereto. This changes the path of the current from the motor to the high resistance slot coil through wires 8 and 9, contacts 10 and 11 and wire 12 to common. When the control circuit is broken the slot dog, actuated by the slot lever, disengages from the stud on the main gear, as shown in Fig. 434. The signal returns to the stop or caution position, and the buffer dash-pot takes up the concussion and prevents undue strain upon the apparatus.

Fig. 432. Model 5 Motor Mechanism; Signal in Stop Position.

Fig. 433. Model 5 Motor Mechanism; Signal Clear.

Fig. 434. Model 5 Motor Mechanism; Slot Disengaged; Signal Beginning to Assume Stop Position.

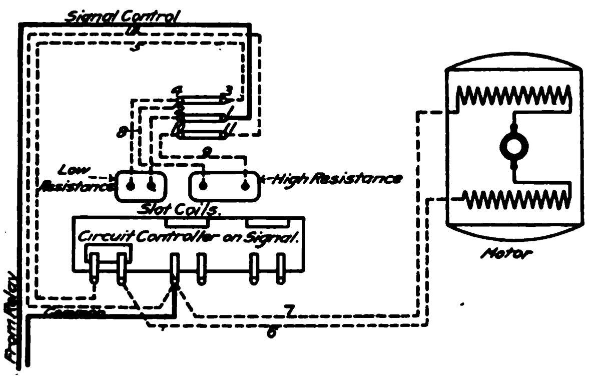


Fig. 435. Local Wiring for Model 5 Motor Mechanism.

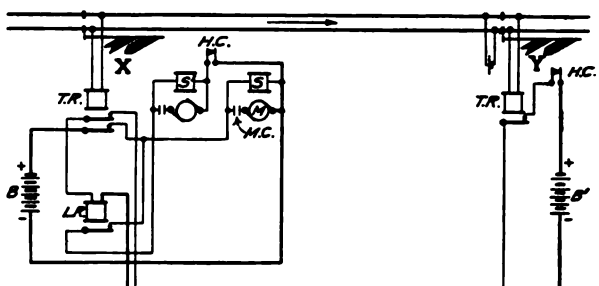


Fig. 436. Wiring Diagram for Two-Arm Automatic Signal, Model 5.

Fig. 436 is a wiring diagram for a two-arm signal, when the top-post mechanism is used; one is provided for each arm.

Fig. 437. Three-Position Automatic Signal as Used on the Baltimore & Ohio. General Electric Company.

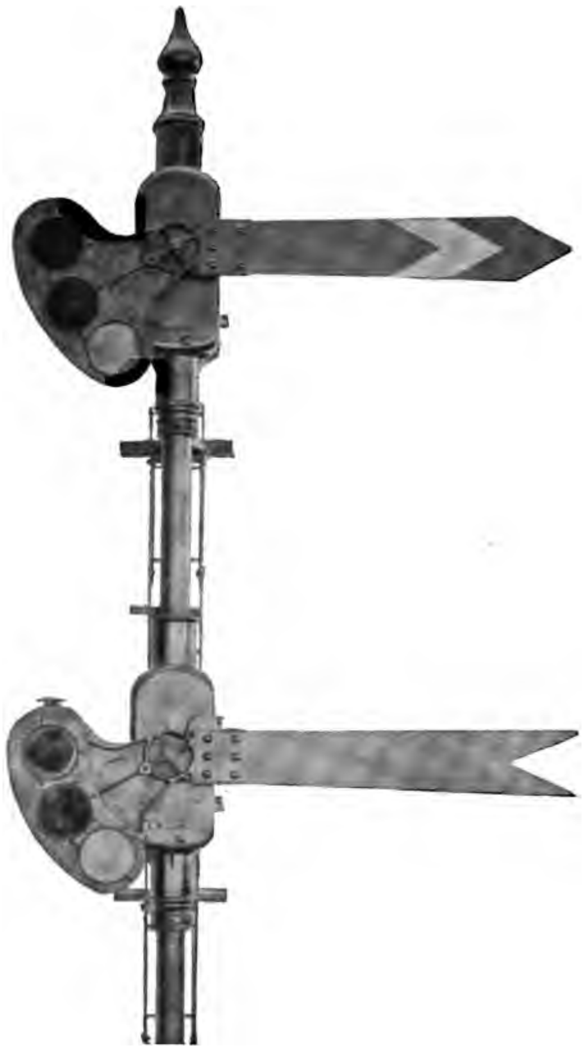


Fig. 438. General Electric Automatic Signal as Used on the New York Central & Hudson River.

SPINDLE MECHANISM. GENERAL ELECTRIC COMPANY.

Fig. 439 shows the Style M-110 signal mechanism made by the General Electric Company. On the case are mounted the lamp bracket and pinnacle. When equipped with blade and spectacle these form a complete unit, which may be mounted upon any suitable post, bridge or bracket. The case measures 27 in. long by 13 in. wide, and is not noticeable when erected. On the inside of the larger door is a pin which serves to hold the glass commutator cover when it is removed for inspection of the motor. The mechanism (Fig. 439a) is operated by an electric motor which is supplied with current from storage or primary batteries, usually at a potential of ten or twelve volts. The motor is geared so as to revolve the clutch wheel which turns freely about the main shaft. This shaft extends through the back of the case for the reception of the signal arm. Mounted upon the main shaft and rigidly attached thereto is the sector casting which supports the clutch magnet and its toggle levers, which engage with the clutch wheel when the magnet is energized, thereby causing the main shaft to be rotated by the motor. At the top of the mechanism is seen the lock or slot magnet for holding the signal in its caution or clear positions. When the lock magnet is energized a system of toggle levers, identical with that of the clutch, engages with locking points on the sector casting. The free gravity movement from clear to caution and to stop positions, is accomplished without the movement of any of the gearing, and is retarded by the dash-pot at the front of the mechanism connected to the crank on the main shaft. The main shaft also supports the controller segments by means of which the various circuits are made and broken through the contact fingers which are supported on studs rigidly secured to the frame.

The motor, while being of standard design, embodies some special features. The field coils, like all other coils in the mechanism, are wound with a special flexible enamel covered wire which possesses high insulation resistance and withstands a high puncture test. The pole pieces are built of a special grade of laminations. The armature coils are wound in slots in a laminated core, and after being baked at a high temperature are subjected to the vacuum insulating process, which thoroughly impregnates the armature with a compound of high insulating properties. The commutator is composed of copper bars of uniform hardness, mica insulated. Brush-holders and brushes are easy of access, the springs exerting a uniform pressure between the brushes and the commutator, and an easily removable commutator cover is provided.

All parts of the signal mechanism are interchangeable. The toggle levers are composed of a non-corrosive nickel alloy and the gears and clutch wheel are of cast-iron; the pinions are of steel. Bearings are of bronze. The contact fingers are firmly fixed on square insulated studs, and are non-adjustable. The contact sectors are firmly fastened to the main shaft, an extra adjustable circuit control being provided. The contact sectors and fingers are composed of a special non-corrosive alloy. The side frames are of cast-iron, with solid webs. The entire mechanism, when assembled, is strong and rigid, and, apart from the brushes, requires no adjustment. This non-adjustable feature of the mechanism makes it suitable for location at the top of the mast, as maintenance is reduced to a minimum, the only attention required being that for lubrication and inspection of the commutator and brushes. A seat is provided at the top of the post for the maintainer. This signal is adapted to two-position and three-position operation, and the design of the mechanism case is such that a signal may be inserted in the post at any desired point. Thus two or more signals, with independent mechanisms, may be operated on the same signal post. This arrangement is shown in Fig. 438, which illustrates an electric top mast home and distant motor signal with independent mechanisms on the New York Central. Fig. 437 shows the signal as used on the Baltimore & Ohio.

The signal, shown in Fig. 440, and known as the Style M-113, is primarily a two-position mechanism. The back view of the signal mechanism is shown in the position corresponding to the proceed indication of the arm. The supporting frame of this mechanism, carrying the bearings for the shaft and gearing, also forms the case, which is weather-proof. The bottom of the case *A* forms a socket by which it is secured to the top of the post, and inside this socket is a removable insulating bushing *B* which eliminates possibility of grounding, even if the wiring comes in contact with the case or an insulation is broken down. A similar socket *C* is provided at the top of the case to hold the pinnacle, or for an extension of the mast, in case one or more signals are to be placed above it.

The form of the case is such that, with a suitable bracket (*D*) for supporting the lamp, any of the present standard semaphore spectacles may be used. The motor is similar to that used in the other type of the General Electric Company's signals, except that it is provided with both series (*E*) and shunt (*F*) field winding, and with a ball ratchet to prevent backward rotation of the armature. The object of this modification is explained below.

The high speed gear and the motor pinion are protected by a case attached to the inside of the frame, while the intermediate gear

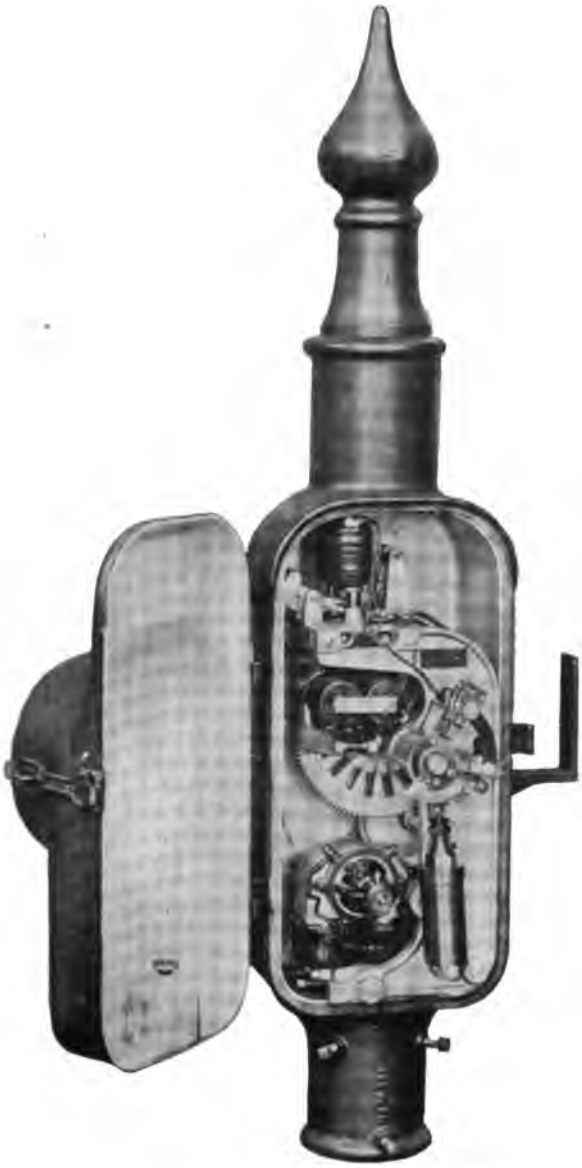


Fig. 439. Electric Motor Signal Mechanism, Style M-110.

Fig. 440. Electric Motor Signal Mechanism, Style M-113.

Fig. 439a. Motor Signal Mechanism, M-110.

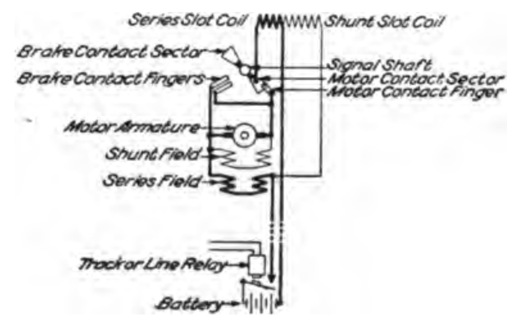


Fig. 440a. Local Wiring for Motor Signal.

and its pinion are protected by a gear case made of a single piece and bolted to the outside of the frame, with which it makes a weather-proof joint. To the face of the main gear *G* are attached driving pins of case-hardened steel, which move the signal from stop to proceed position by engagement with the pawl *H* of the slot-arm. The slot-arm *J* is mounted on a squared portion of the signal shaft by means of a broached hole in its hub, and carries a magnet *K*, the armature *L* of which is attached to one end of a bell crank lever, which by a pawl at its other end engages with the driving pins whenever the slot-magnet is energized. The series coil of the slot-magnet is connected in the motor circuit, and the shunt or high resistance coil is connected outside of the control contacts which break the motor circuit. Current is carried to the slot-magnet without the use of flexible moving wires, segmental collector rings and brushes being employed as in other G. E. signals.

Fig. 441.

Fig. 442.

Mechanism for American Railway Signal Company's Semaphore Signal.

On the signal shaft, directly behind the main gear, is mounted an eccentric *M*. The strap of this eccentric is cast in one piece with the cylinder of the dash-pot, or buffer *N*. In front of and connected to the main shaft is a counting device *O* for registering the number of signal movements.

When the signal circuit is closed (Fig. 440a) current will flow through the shunt coil of the slot-magnet, and in another circuit through its series coil, and thence through the motor control sector *P* and its contact fingers *Q* to the motor. The slot-magnet being energized, the pawl *H* is held in the path of the driving pins, and as the motor revolves one of these pins is forced against the pawl, thereby turning the slot-arm and the signal shaft to which it is connected, thus carrying the signal arm toward the proceed position. When the arm of the signal comes almost to its extreme "proceed" position, the motor current is broken by means of the controller *P*, but this breaking of the current does not arrest the movement of the signal, for the inertia of the revolving armature and other parts keep it going. With the shunt field winding, the motor driven by its own inerita becomes a generator, maintaining its field excitation. Immediately after the circuit between the motor and the battery is broken, a low resistance circuit is closed between the motor brushes, thus converting the motor into a powerful electric brake to arrest further movement of the signal. As soon as the motor stops, the ball ratchet, above mentioned, prevents any backward rotation of the armature, and the signal is thus held in its clear position until the main circuit between the signal and the battery is opened. The circuit-closer for electric brake control is shown in the cut at *R*. At *S* are a number of closers for extra circuits. The glass cover of the commutator cover is shown removed at *T*.

It will be understood that the higher the voltage of the battery and the less the friction of the machine, the greater will be the speed of the motor at the time the battery current is cut off, and the greater will be the inertia of the moving parts. It is also evident that the greater the speed of the motor the higher will be the E. M. F. generated in its armature, and the greater will be the current opposing its forward movement when it is acting as a generator. Therefore the motor will make approximately the same number of revolutions after its current is broken, stopping the signal arm at the same position under all conditions; so that a friction brake is not needed.

When the main signal circuit is opened and the slot-magnet de-energized, its heavy armature falls away from the poles, this movement being also assisted by the pressure of the driving pins against the pawl. The pawl being thrown back from engagement with the driving pin, the signal is free to assume the position to which it is normally carried by gravity. As the signal arm comes to its stop-position, the rotation of the slot-arm causes its armature to swing back against the poles of the magnet, so that it is in position to be held firmly in place when current is again applied.

While this signal was specially designed for use in two positions only, it can be operated as a three-position signal when an extra circuit controller is used, and a back contact provided on the line relay. When used as a three-position signal, and when indicating a train backing into the section of track for which the signal gives distant indications, the arm will go from clear to stop before assuming the caution position. Where such a movement is not objectionable this signal is applicable. The design is such that all parts are readily accessible, and they are easily removed from the case, when necessary. The motor and other parts are readily reversible to provide for moving the arm either up or down from the horizontal position.

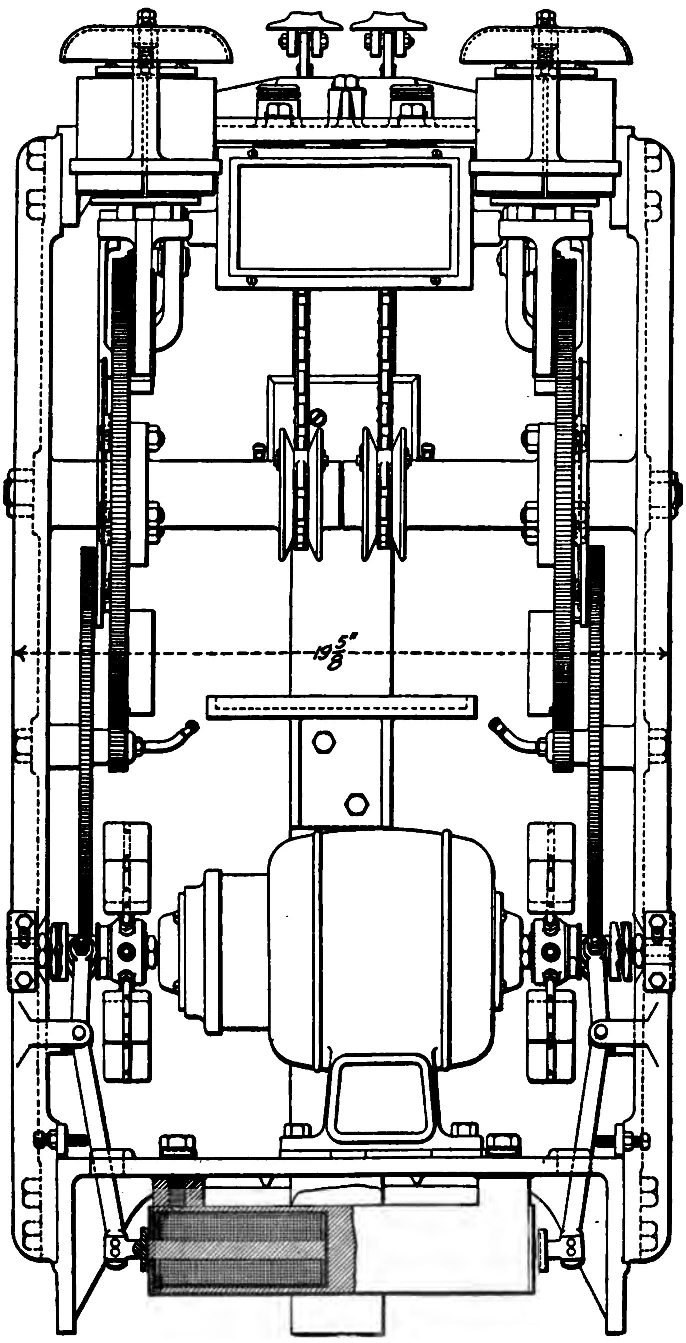


Fig. 443.

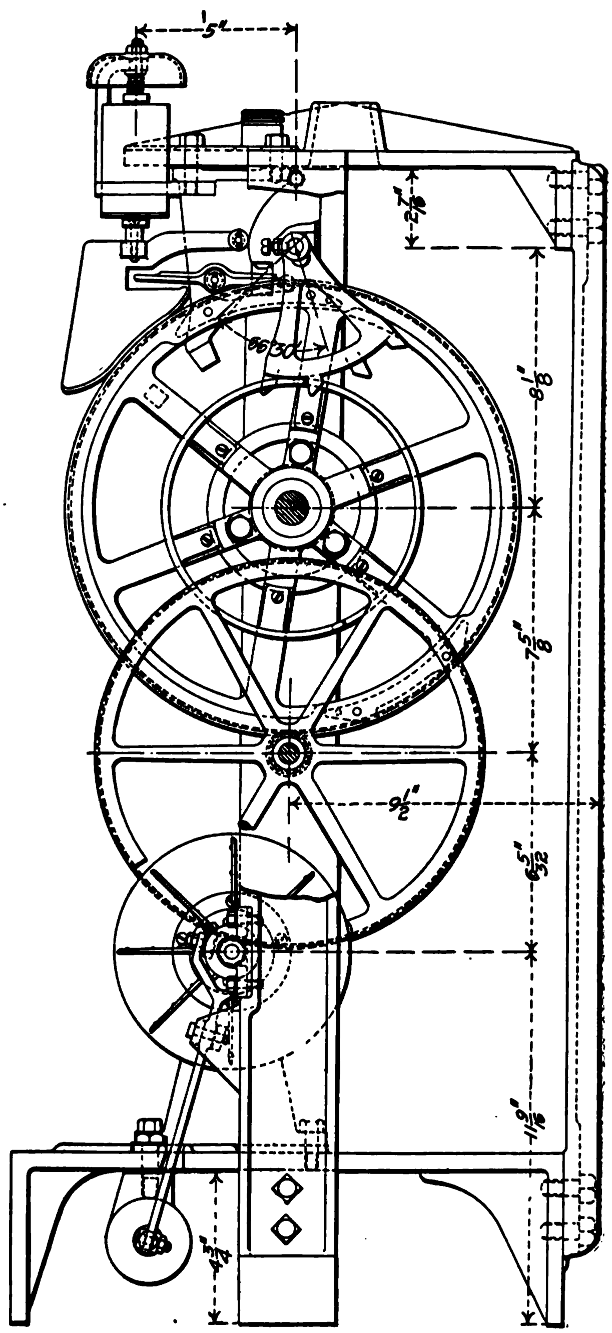


Fig. 444.

American Railway Signal Company's Electric Semaphore Signal Mechanism.

MOTOR MECHANISM.

AMERICAN RAILWAY SIGNAL COMPANY.

Figs. 441-444 illustrate the two-arm electric motor mechanism made by the American Railway Signal Company. The distinguishing feature of this mechanism is the use of a revolving fan instead of a dash-pot for preventing shocks when the signal moves by gravity to the stop position. This fan also causes a circulation of air in the case, tending to prevent the accumulation of frost and ice on the moving parts. While the motor is engaged, the fan remains idle, adding nothing to the work of the motor. The same mechanism can be used to operate a one-arm signal for either two or three positions; or a two-arm signal for either two or three positions, the arms to be moved separately or both at the same time, and the arms may be moved in either the upper or the lower quadrant. The arm may be stopped at any angle and immediately returned to the position giving the desired signal indication without first going to the stop position. The circuit controller is enclosed in a water-tight case. With this mechanism the signal is pulled to the clear position so that the vertical rod need not be so heavy and stiff as where the signal is cleared by pushing the rod upward. The motor is enclosed in a dust-proof case, with a glass covering over the commutator. The clutch which causes the motor to engage with the gears is operated by a magnet which is in series with the motor. This clutch is enclosed in a water tight iron case bolted to the underside of the plate supporting the motor, and it acts through vertical rods, which may be seen at each side (Figs. 441 and 442) projecting through the base plate. The object of the clutch is to cut the motor clear of the mechanism as soon as the arm has been brought to the clear position. The mechanism operates the arm by means of a ¼ in. prosphor bronze rod of 2,100 lbs. tensile strength. The signal is held clear by means of clutch magnets, seen at the top of the illustrations. These magnets are protected from moisture or dirt dropping from above by bell-shaped shields. When the signal goes to the stop position it causes the whole mechanism, except the motor, to revolve backwards; and the weight and friction of the parts suitably modified by the fan serve to provide the necessary cushioning to prevent any shock when the signal arm comes to its normal position.

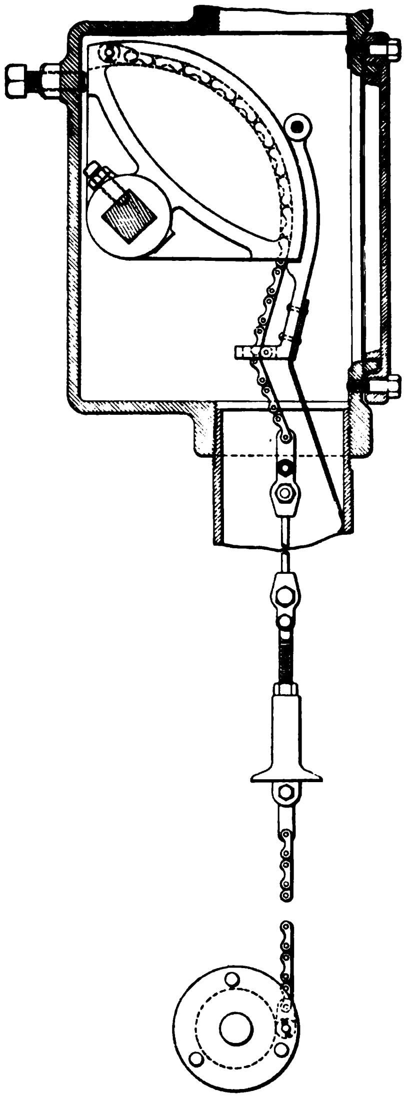


Fig. 445. Mechanical Semaphore Lock on American Railway Signal Company's Motor Signal.

Fig. 445 illustrates the connection of the operating rod or chain to the semaphore shaft, the signal and arm being now in the stop position. The chain lies in a groove in the sheave. Having been slackened, to permit the arm to assume this position, it has been forced in toward the shaft so that it does not hang in a straight line. It is kept in this position by the flat spring attached to the lock dog, and the lug on the lock dog prevents the shaft from being turned. When power is applied to the chain it is pulled taut, and this throws the dog clear of the sheave.

MOTOR MECHANISM

FEDERAL SIGNAL COMPANY

The signal mechanism made by the Federal Signal Company is arranged to operate either one or two arms. It is composed of the two upright stands 1 and 1' (Fig. 446) which are securely bolted to base 2. These frames are connected at the top by the buffer base casting on which are mounted the buffer cylinders 4 and 4'. Two main shafts or spindles 5 and 5' turn in bearings 6 and 6' formed in the frames 1 and 1' additional bearings 7 and 7' are formed in the bracket 8 which is bolted to the frame 1 and 1' and acts also as a tie for the frames. The shafts 5 and 5' turn in bearings 7 and 7'. On the outside of the frames 1 and 1', mounted on the shafts 5 and 5' are the main driving gear wheels 9 and 9'. A shaft or spindle 10 is mounted in bracket bearings 11 and 11', which are secured to frames 1 and 1', respectively. Upon this shaft 10 is secured the worm wheel 12 which meshes with and is driven by the worm 13 on the shaft 14 of the motor 15. Bracket support 17, carries a thrust bearing 16 for the worm 13. The flexible connection 18 in the motor shaft 14 is employed to relieve the motor from any friction due to the thrust of the worm 13. On the shaft 10 are loosely mounted the pinions 19 and 19' which mesh with the gear wheels 9 and 9' respectively. A clutch sleeve 20 is also fixed to the shaft 10 and turns with it, but it also arranged to slide from side to side. This is accomplished by a slotted hole in the sleeve 20 and a pin in the shaft 10. On the extreme ends of the sleeve 20 are cut notches or teeth 21 and 21' which engage with similar teeth 22 and 22' of the pinions 19 and 19'. A grooved collar 23 is formed in the sleeve 20 and is operated by the lever 24, which is riveted at 25 on the frame 1. On the spindles 5 and 5' between the bearings 6 and 7 and 6' and 7' are secured the operating cranks 26 and 26'. To one end of each of these cranks are connected jaws, as shown at 27, to which are attached the up and down rods 28. The opposite ends of the cranks 26 and 26' are connected by the rod 29 to the buffer piston 30. On the lower edge of the crank 26 is bolted a lug 49, in the curved face 50 of which is cut a cam groove 51. This groove, when rotated, forces the end 52 of the lever 24 from right to left. This operates the clutch sleeve 20 from left to right, thus disengaging it from the pinion 19 and engaging it with the pinion 19'. The caps 31 and 31' of the buffer cylinders 4 and 4' are fitted with adjustable air vents 32, and the pistons 30 and 30' are fitted with ball valves 33, which open and allow the air to enter the cylinders 4 and 4' during the downward stroke of the pistons and close to prevent the air from escaping back through the pistons during their upward stroke.

Outside the main gears 9 and 9' on the shafts 5 and 5' are secured the magnet supports 34 and 34' on which are bolted magnets 35 and 35', supporting armatures as shown at 60. Armature levers 36 and 36' are pivoted to lugs 37 and 37' of the support 34 and 34'. The shorts ends 38 and 38' of the levers 36 and 36' connect by pins 39 and 39' with the long ends of the links 40 and 40' which are pivoted on pins as shown at 41. The short ends of the links 40 and 40' project outward toward the periphery of the main gears 9 and 9' in the path of the roller studs 42. These studs are situated on the sides of the gears, and as many as are required may be used. A counterweight pawl 43 is attached to the frame 1 by pivot stud 44. The tooth 45 of the pawl rests at certain times between the teeth of the gear wheel to prevent the wheel 9 from revolving backward. Another tooth 46 is also fixed to the side of pawl 43; this tooth is somewhat longer than the tooth 45 and normally rests in one of the notches 46 which are formed in the edge of the rim of the gear 9. This edge 48 is formed by reducing the face of the gear 9 to a depth even with the bottom of the teeth of the gear. Circuit controlling devices 53 and 53' of a quick break type are fastened to the base 2 and are connected to and operated by the cranks 26 and 26' through the rods 54 and 54'.

If the top or home arm is to be cleared the coils of magnet 35 are energized by closing a circuit from a source of energy. The magnet will hold the armature 60 against its poles and thus maintain the lever 36 and the link 40 rigidly in the position shown. If current be now applied to the motor 15 its armature will revolve and through the medium of its shaft 14 and clutch 18 will cause worm 13 to revolve, which will, in turn, rotate worm wheel 12 and shaft 10. Shaft 10 in turning will revolve the pinion 19 through the medium of the sleeve 20, the left-hand teeth of which engage with the teeth of the pinion 19. The pinion 19 meshing with the main gear 9 which is loosely mounted on the shaft 5 will now revolve, and one of the studs 42 which are mounted thereon will strike against the projecting end of the link 40. In so doing the magnet arm 34, which is rigidly attached to shaft 5, will be partially revolved turning shaft 5 with it and also crank 26, which is also rigidly attached to the shaft. Crank 26 in swinging will lift the up and down rod 28 sufficiently to move the signal blade the required distance. At this point the circuit controller 53, which is actuated by the crank 26, will cut off the current from the motor 15, but not from the magnet 35. The crank 26 will also actuate the shifting lever 24 and throw the clutch sleeve over from left to right, disengaging pinion 19 and engaging pinion 19'.

While gear 9 has been revolving the tooth 46 of the pawl 43 has been resting against the surface 48 of the gear 9, thus holding the tooth 45 out of engagement with the teeth of gear 9. At the same instant, however, that the clutch sleeve 20 is released from pinion 19, the notch 47 in the edge 48 of the gear 9 arrives at a point adjacent to the tooth 46 of the pawl, thus allowing the pawl to swing and its tooth 45 to engage with the teeth of gear 9, arresting any backward movement of the gear. The signal arm thus cleared will remain so as long as magnet 35 remains energized. If the lower or distant arm is to be cleared the motor 15 is again energized by a circuit through the distant controller 53' and magnet 35'. The clutch sleeve 20 being now in engagement with the pinion 19' will cause the pinion to revolve transmitting its rotary motion to the main gear 9', clearing the distant signal in the same manner as the home signal was cleared.

Upon the de-energization of the magnets 35 or 35' the respective signals will, on account of their counterweight, return to stop without turning backward either of the gears 9 or 9'. This is accomplished as follows: When the armature 60 is released, the weight resting on the lever 26 will cause the lever 36 and link 40 to hinge or toggle at point 39, this toggling will withdraw the projecting end of link 40 from its point of contact with the roller stud 42 and allow the crank 26 to come to rest. This returning movement is retarded by the buffers 4 or 4'. The distant signal in going back to normal position does not in any way affect the clutch sleeve 20, which still remains in connection with pinion 19'. Therefore, if the distant section of track governed by this signal be occupied and vacated the signal will automatically return to its normal position and then clear again without affecting the home mechanism. If, however, the home section should be occupied the home signal would return to stop position, and in so doing would throw back the clutch sleeve from pinion 19' to pinion 19, thus rendering it impossible to clear the distant signal again until the home section was vacated and the home signal cleared. This apparatus can be made if desired, to operate a single signal by leaving off the right-hand portion of the mechanism.

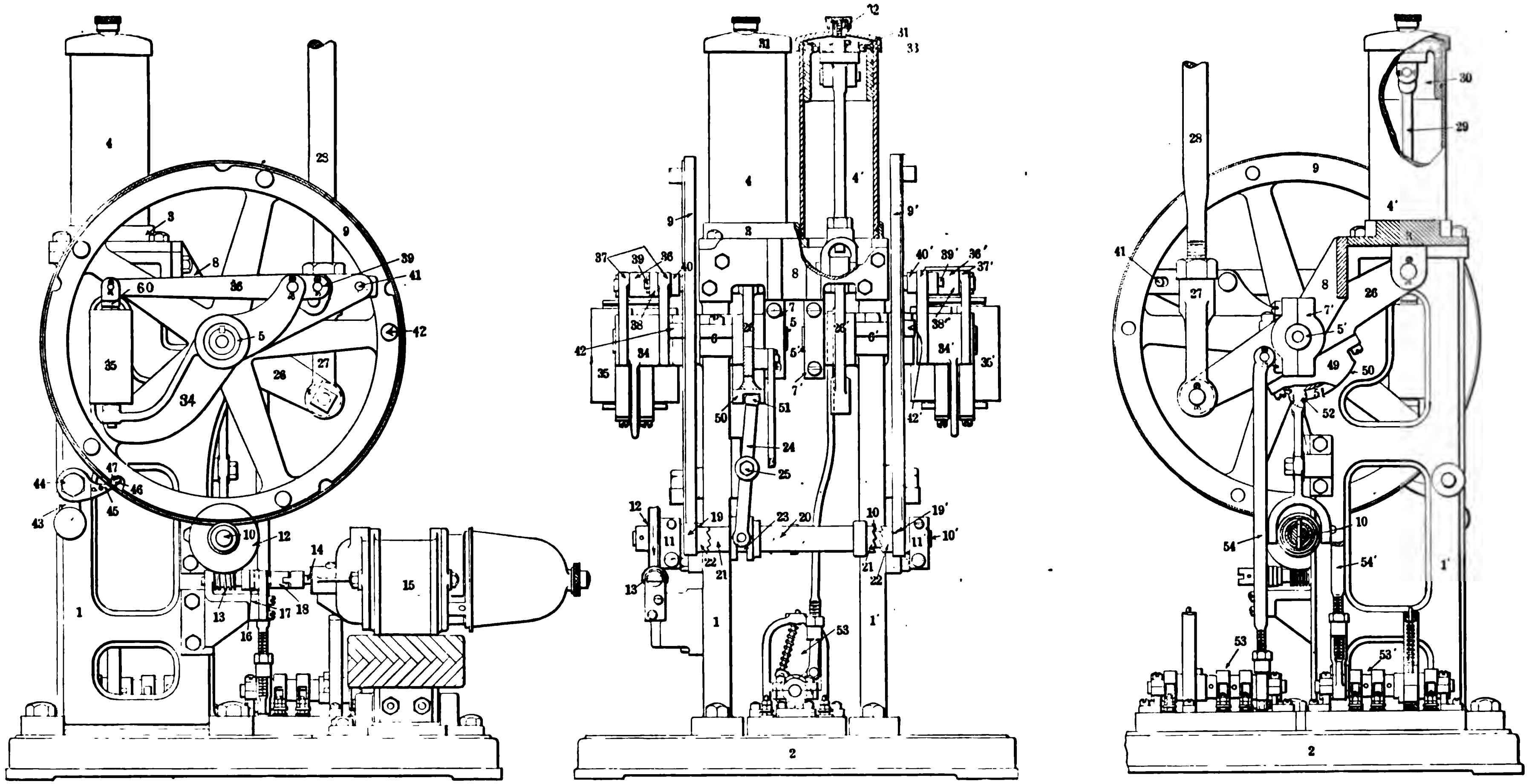


Fig. 446. Motor Signal Mechanism. Federal Signal Company.

Names of Parts of Fig. 446.

1 *Frame Uprights*
2 *Base*
3 *Buffer Base*
4 *Buffer Cylinders*
5 *Main Shafts*
6 *Main Shaft Bearings*
7 *Main Shaft Bearings*
8 *Bracket*
9 *Main Gear Wheels*
10 *Clutch Spindle*
11 *Clutch Spindle Bearings*
12 *Worm Wheel*
13 *Worm*
14 *Motor Shaft*
15 *Motor*
16 *Thrust Bearing*
17 *Bracket Support*
18 *Flexible Connection*
19 *Pinions*
20 *Clutch Sleeve*
21 *Clutch Teeth*
22 *Pinion Teeth*
23 *Collar*
24 *Clutch Lever*
25 *Rivet*
26 *Operating Cranks*
27 *Jaw*
28 *Up-and-Down Rod*
29 *Buffer Piston Rod*
30 *Buffer Pistons*
31 *Buffer Cylinder Cap*
32 *Adjustable Vent*
33 *Ball Valve*
34 *Magnet Support*
35 *Slot Magnet*
36 *Armature Lever*
37 *Lugs*
38 *End of Lever 36*
39 *Pin*
40 *Link*
41 *Pivot Pin*
42 *Roller Stud*
43 *Counterweight Pawl*
44 *Pivot Stud*
45 *Tooth of Pawl*
46 *Tooth of Pawl*
47 *Depression in Wheel*
48 *Edge of Wheel*
49 *Lug*
50 *Face of 49*
51 *Cam Groove in 50*
52 *End of 24*
53 *Circuit Controller*
54 *Circuit Controller Operating Rod*
60 *Armature*

Numbers Refer to List of Names of Parts on Page with Figs. 461-464.

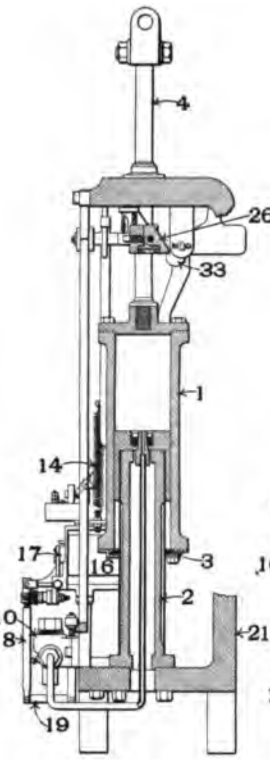


Fig. 447.

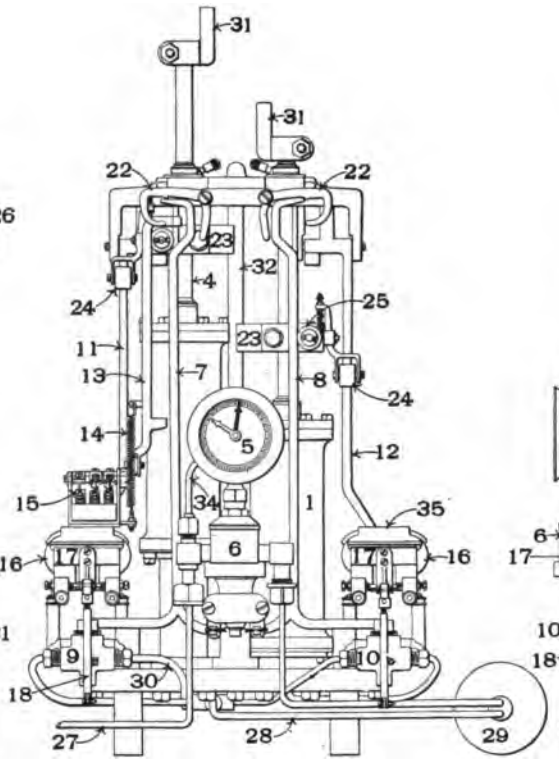


Fig. 448.

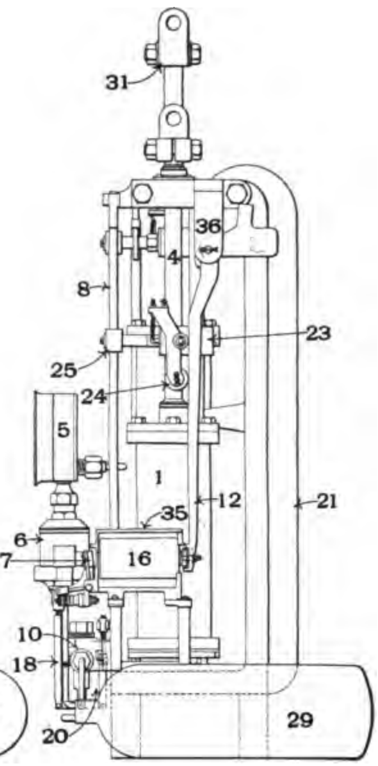


Fig. 449.

Hall Electro-Gas Signal Mechanism for Two-Arm Semaphore.

THE ELECTRO-GAS SIGNAL.

Figs. 447-449 illustrate the two-arm electro-gas signal mechanism made by the Hall Signal Company. Single arm mechanism are similar to these, except that they have only half as many moving parts. In Fig. 448 one-half of the mechanism is shown in the position for a clear indication and the other half for the stop indication. The controlling power of this signal is electricity, the operating power liquefied carbonic acid gas. The gas, stored in an iron cylinder (Fig. 453) at the foot of the signal post is normally at a pressure of from 600 to 1,200 lbs. per sq. in., and for use is reduced through a regulating valve (Fig. 452) to from 40 to 60 lbs. pressure per sq. in. Pipe 27, Fig. 448, leads to the mechanism from the main receptacle. The signal rod which operates the semaphore arm is connected to the clamp 31, attached to the cylinder rod, and the gas when admitted to the cylinder 1 causes the cylinder and its rod to move upward and the arm to assume the clear position. The cylinder is movable and its piston is fixed. The flow of gas into the cylinder and its egress therefrom are controlled through valves 9-10, Fig. 448 (shown enlarged in Fig. 451), which in turn are controlled by the electro-magnets 16. The lever or clutch which holds the signal clear is controlled by a back armature on these magnets. When the magnets are energized the front armature 17 is attracted. This armature is attached to a pivoted crank, to one arm of which a connecting rod 16 is fastened. The valves which control the flow of gas into the cylinder and its escape therefrom are controlled by this connecting rod so that when the armature is attracted the supply valve is opened and the exhaust valve closed, which makes a free path for the gas from the tank to the cylinder. This path from the gage and regulator 5-6 is through the expansion chamber and its connection 29, through the valve 9, which has been opened by the movement of the armature, through tube 30 to the inside of the cylinder 1. The pressure causes the cylinder to move upward on its piston and clear the signal. Clutch casting 23 is clamped to the cylinder rod and moves with it along the guide 32. Roller stud 25, screwed into the clutch casting 23, moves along cut-off lever 8 until it raises pawl 22, which is pivoted on a stud screwed into the frame, 21. Cut-off lever 8 is shaped like an inverted T and is pivoted on its left leg at the bottom. The right leg is connected to one end of the link 20. The cut-off lever is counterweighted, so that when free to move on its pivot it will force the link 20 down and close the supply valve. At the same time the exhaust valve will be opened, as the two valves are connected and any movement which closes one opens the other. As soon as pawl 22 has been raised by roller 25, cut-off lever 8 is released, closing the supply valve, which stops the flow of gas into the cylinder and opens the exhaust valve and allows the gas which has been used in the cylinder to escape.

It is apparent that the gas has been used only to raise the cylinder, not to hold it in its new position. This latter function is performed by the clutch lever 12, which is suspended on pivoted bearing 36. The top of this lever has a nose-shaped projection which engages a latch on the back of clutch casting 23. The lower end of clutch lever 12 carries an armature for magnet 16, and when the magnet is energized the clutch lever is held in such a position that the latch on casting 23 rests on the nose of clutch lever 12 and holds the signal in the clear position. When the magnet becomes de-energized clutch lever 12 is released and the counterweight of

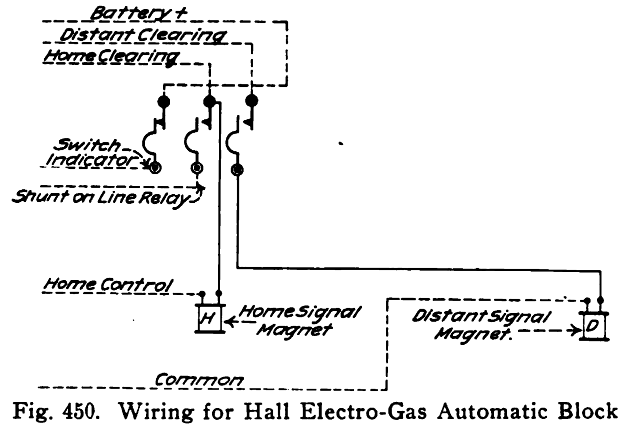


Fig. 450. Wiring for Hall Electro-Gas Automatic Block Signal; Normal Danger, Double Track.

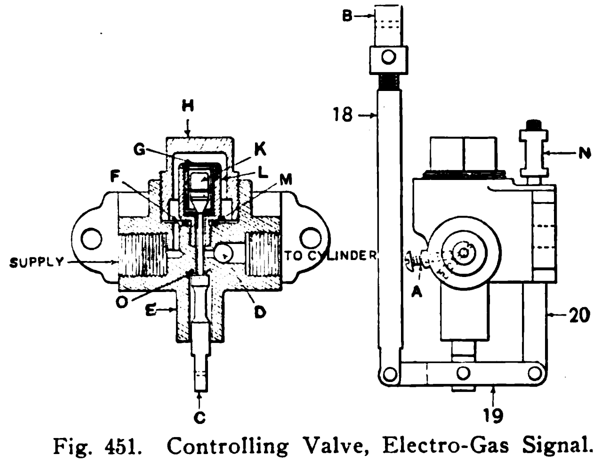


Fig. 451. Controlling Valve, Electro-Gas Signal.

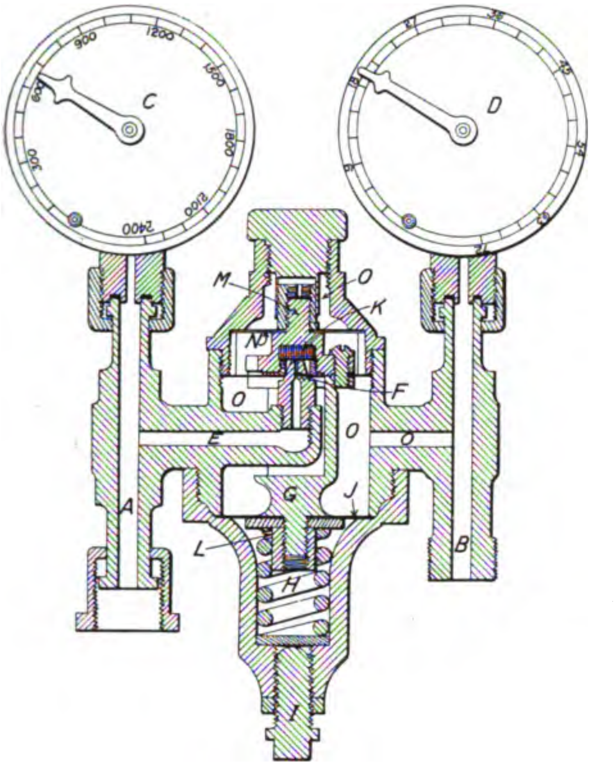


Fig. 452. Reducing Valve for Electro-Gas Signal. Hall Signal Company.

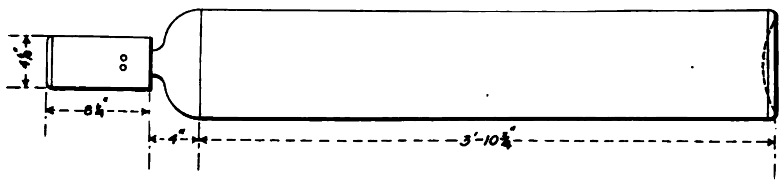


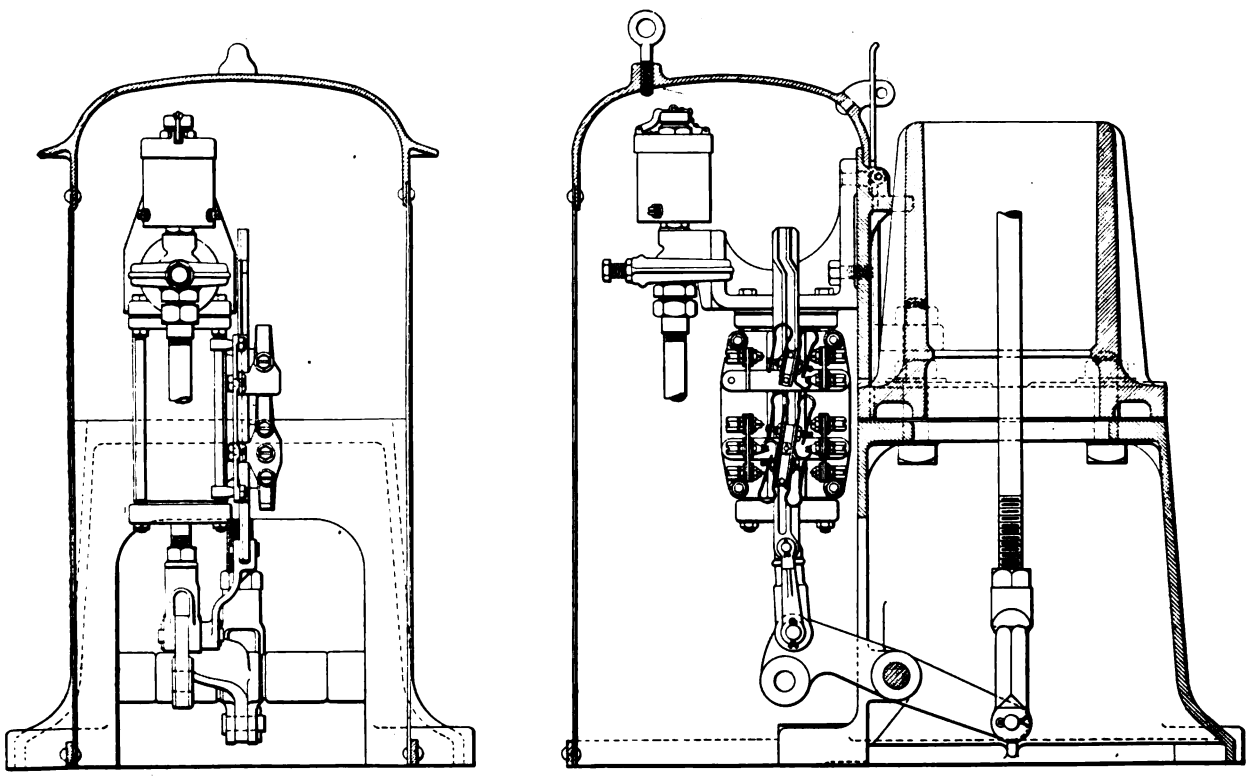
Fig. 453. Standard Cylinder for Liquid Gas. New York Central & Hudson River.

the signal, falling, causes clutch lever 12 to fly backward on its pivot 36 a sufficient distance to allow the latch and clutch casting 23 to pass the projection on the clutch lever 12; and the signal drops to the stop position. The escape of the gas or air from the cylinder through the exhaust valve is so regulated that the piston and cylinder become a dash-pot, preventing any violent drop of the cylinder when the signal assumes the stop position. Circuit breaker 15 used to control the distant and other circuits, is shown in Figs. 414-416. It is operated by rod 13 through a crank. The upper end of rod 13 is bent at right angles and has a lug, as shown. Roller 25 moves 13 up by striking against the bent top or down by striking the lug. Spring 14 will pull 13 down in case the lug should break. Cut-off lever 7 is left handed and 8 is right handed, and the same is true of 11 and 12.

The piston and cylinder are made of phosphor-bronze, ground to a true fit. The cylinder being inverted and moving on the piston, it can have a solid head, certainly preventing the entrance of water. Its pedestal has a brass bushing.

Fig. 451 shows the controlling valves (9-10, Figs. 447-449) in detail. Parts 18-19-20 are the same as those of corresponding number in Figs. 447-449. Adjustable connections N and B are attached to the front armature and to rod 7 or 8. The body of the valve E has a cover H; K is the valve itself, with stem connected to C, and L is the valve guard and seat; F is a washer; D is a steel ball serving as a check to retard the exhaust of gas from the cylinder so as to form a cushion between the cylinder head and the piston. D is kept from completely blocking the passage by adjusting screw A. Gas is admitted at the left and passes up and over L. When K is raised from its seat, C seats at O and gas passes around K and D to the cylinder. When C is lowered K seats and is held seated by the pressure of the gas. The exhaust passes from the cylinder, around D and down around the stem of K and C to the atmosphere.

Fig. 452 is an enlarged view of the regulating valve 6, Figs. 447-449, though in those illustrations only one gage is shown instead of two. The single gage has two hands, one for the high pressure and one for low. It is mounted centrally and a pipe leads to it from the coupling where the high pressure gage is mounted in Fig. 452. The functions of the various parts and the operation of the valve are as follows: Gas enters the valve body through E, which is connected to the high pressure gage C, and reaches valve seat F. Before the gas is turned on, the adjusting screw I is unscrewed so that there is no pressure on the spring H; then the diaphragm J tends to hold the hard rubber valve disk K down on the seat F, and when the gas is turned on prevents it from escaping to any extent. Then the adjusting screw I is screwed in. This puts pressure on spring H. The top of this spring bears on the flange L and raises it, with all the parts connected to it, which includes the



Figs. 454-455. Electro-pneumatic Signal Mechanism. Union Switch & Signal Company.

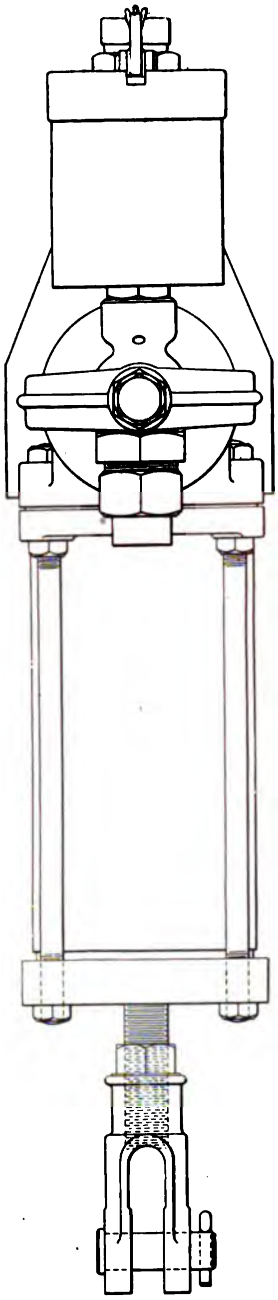


Fig. 456.

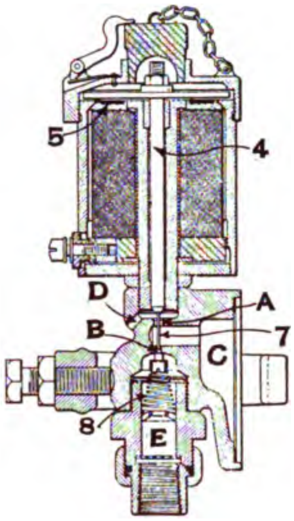
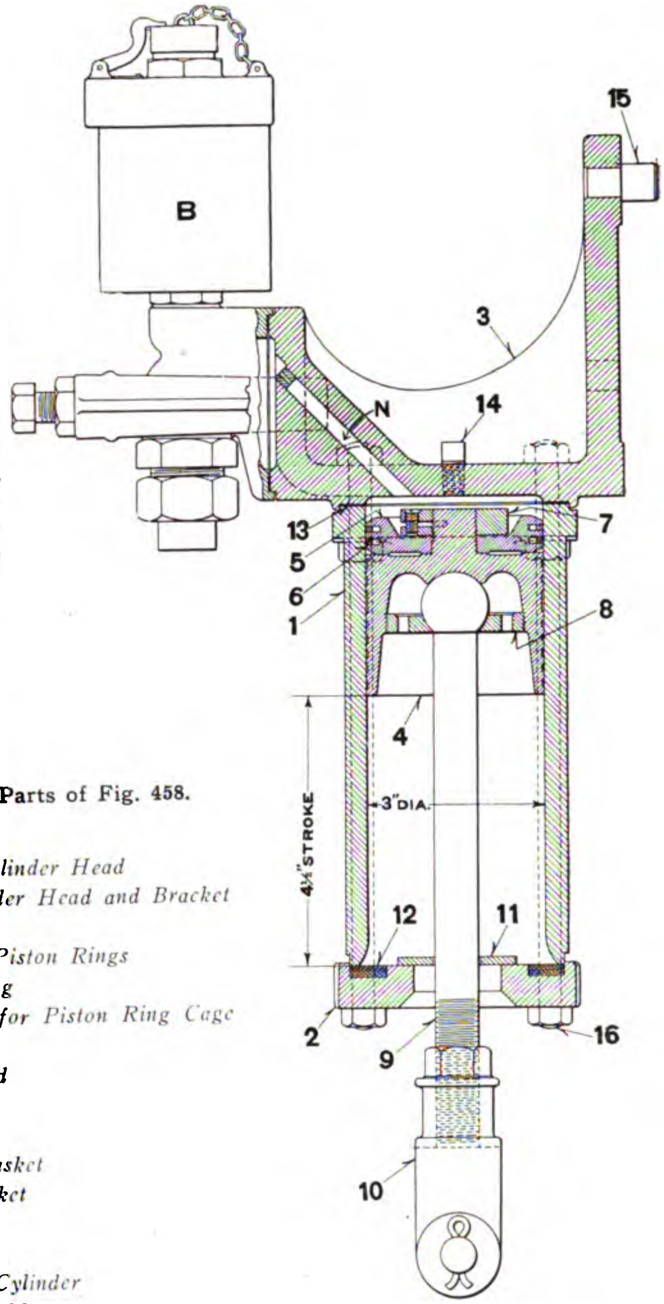


Fig. 457.



Names of Parts of Fig. 458.

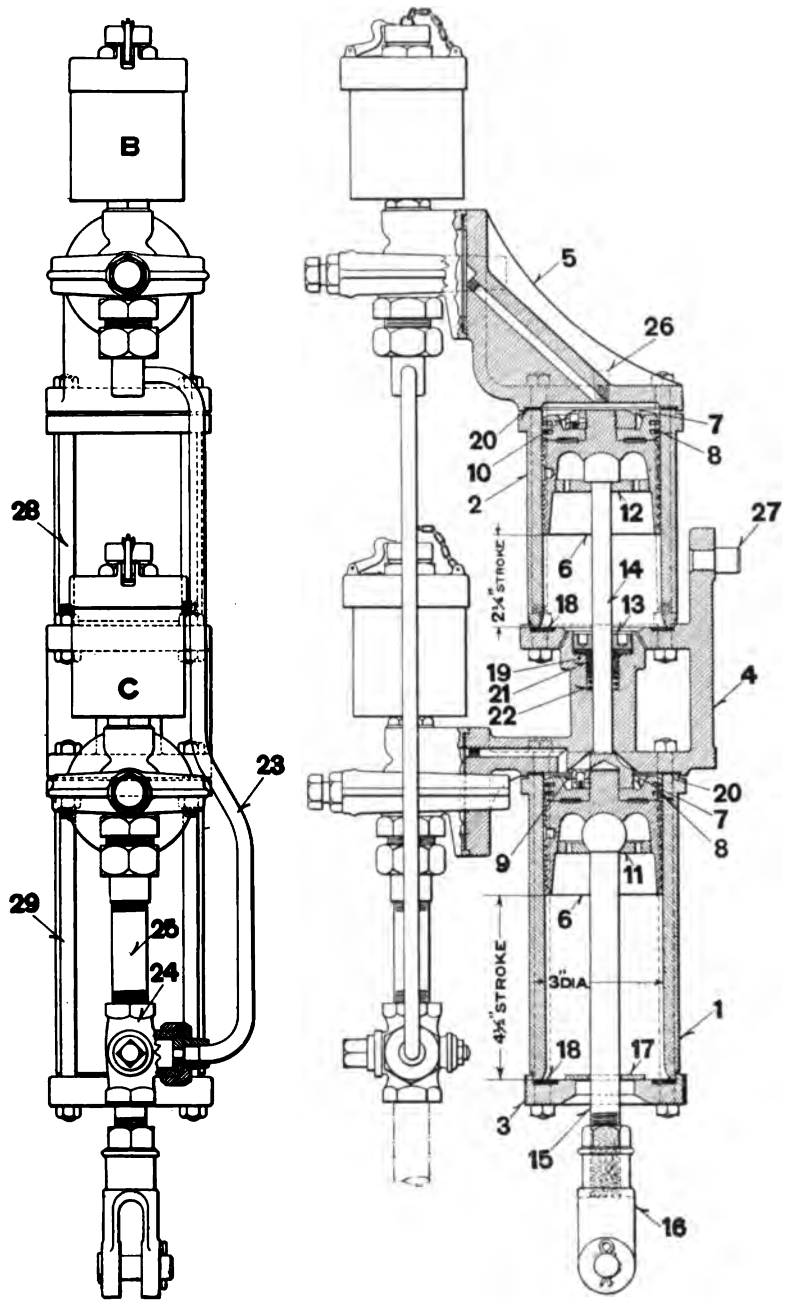
1 *Cylinder*
2 *Bottom Cylinder Head*
3 *Top Cylinder Head and Bracket*
4 *Piston*
5 *Cage for Piston Rings*
6 *Piston Ring*
7 *Lock-Nut for Piston Ring Cage*
8 *Ring Nut*
9 *Piston Rod*
10 *Jaw*
11 *Washer*
12 *Leather Gasket*
13 *Fiber Gasket*
14 *Oil Plug*
15 *Dowel Pin*
16 *Stud for Cylinder*
B *Pin Valve Magnet*

Fig. 458.

Figs. 456-458. Details of Electro-pneumatic Cylinder, Magnet and Valve, for Semaphore Signal. The Union Switch & Signal Company.

center of the diaphragm J, the support for disk holder G, the disk holder M with the disk K and the center of the slotted diaphragm N. This operation raises the hard rubber disk K off the seat F and allows the high pressure gas to flow into the chamber O. The gas continues to flow into the chamber O and fills the passage leading to the low pressure gage D, which indicates the pressure. It flows through the pipe leading to the expansion chamber, 29, Fig. 448, which is connected at B. If the valves of the signal mechanism are closed the gas pressure gradually increases in O and the expansion chamber until it becomes great enough on the diaphragm J to force it down and compress spring H. When the diaphragm J is forced down by the gas pressure, the parts attached thereto, including the support for disk holder G, valve disk holder M and the hard rubber valve disk K move with it. When the hard rubber valve disk is forced down it bears on the top of the valve seat F and stops the flow of gas. The gas pressure required to stop the flow of gas is determined by the amount of pressure put on the spring by the adjusting screw. If a higher working pressure is required, the adjusting screw I is screwed in further, putting a greater pressure on the spring H, making necessary a higher gas pressure on the diaphragm J to press the hard rubber valve disk K on the seat F and stop the flow of gas. Unscrewing the adjusting screw reduces the pressure on the spring, and the gas has less pressure to overcome in order to move the diaphragm and the parts attached to it; consequently a lower gas pressure stops the flow of gas. Whenever any gas is drawn from the low pressure side of the regulating valve the pressure is reduced and the spring immediately forces the diaphragm and parts attached to it up which raises the hard rubber valve disk off the seat and allows gas to flow into the low pressure side of the regulating valve, thus keeping the pressure on that side practically constant.

The support for disk holder G is rigidly attached to the center of diaphragm J, and the upper end of the support is securely fastened to the valve disk holder M by means of three screws, thus making one rigid piece. The threaded end of the valve disk holder M projects through a hole in the slotted diaphragm N, and a threaded sleeve is screwed down on the slotted diaphragm N, firmly clamping it between the sleeve and the valve disk holder; thus the parts in which the hard rubber valve disk are held are centrally guided at the lower end by the diaphragm which transmits the pressure to the spring, and the upper end is centrally guided by a diaphragm which is slotted to make it flexible, and also to allow the



Figs. 459-460. Electro-pneumatic Cylinders for Three-position Semaphore, Tandem Movement.

Names of Parts for Figs. 459-460.

1 *Lower Cylinder*
2 *Upper Cylinder*
3 *Bottom Head for Lower Cylinder*
4 *Bracket*
5 *Top Cylinder Head*
6 *Piston*
7 *Cage for Piston Rings*
8 *Piston Ring*
9 *Lock-nut for Lower Piston Ring Cage*
10 *Lock-nut for Upper Piston Ring Cage*
11 *Ring Nut for Lower Cylinder*
12 *Ring Nut for Upper Cylinder*
13 *Stuffing Box Ring Nut*
14 *Upper Piston Rod*
15 *Lower Piston Rod*
16 *Jaw*
17 *Washer*
18 *Leather Gasket*
19 *Leather Packing*
20 *Fiber Gasket*
21 *Gland for Stuffing Box*
22 *Stuffing Box Spring*
23 *Pipe Connection*
24 *Three-way Cock and Union*
25 *Air Inlet for Lower Cylinder*
26 *Oil Plug*
27 *Dowel Pin*
28 *Stud for Upper Cylinder*
29 *Stud for Lower Cylinder*
B *Upper Pin Valve Magnet*
C *Lower Pin Valve Magnet*

pressure to become equal on all sides of it. By using the two diaphragms to guide the valve disk the disk must always seat in exactly the same place.

Fig. 453, the gas tank, is made of steel to withstand a pressure of 3,000 lbs. per sq. in. It has a cover to exclude dust and prevent injury to the couplings and valves while in transit, and has a safety plug which will blow out if the pressure should become dangerous. One tank holds enough gas for several hundred signal movements. Tanks are shipped as needed from a central manufactory and a reserve tank is kept at each signal post.

Fig. 450 shows the local wiring for an electro-gas mechanism, when used in the normal danger systems shown in Figs. 389-391. It is similar to Fig. 411.

THE ELECTRO-PNEUMATIC SIGNAL.

Fig. 457 illustrates the pin valve and its magnet used to control electro-pneumatic signals, made by the Union Switch & Signal Company. The magnet is of the "iron-clad" type. Between the pole piece and the armature there is a spring 5, which assists in releasing the armature when current is withdrawn. The stem 4 of the armature passes down through the center of the magnet and rests on the stem, 7, of the pin valve. The armature stem has a beveled end to seat in the opening below when it is depressed. The pin valve is held against its seat, B, by the pressure of the air at E and also by the spring 8. E is connected to the source of air supply. When the magnet is energized, the armature is attracted and its stem presses down and unseats the pin valve. This admits air to the chamber C. At the same time the end of the armature stem seats at A, so that air cannot escape through the exhaust port D. When the magnet is de-energized the various parts return to their normal position, as shown. This allows air to escape from C to the atmosphere through D and prevents entrance of air from E, through B, to C.

Figs. 456 and 458 show an electro-pneumatic cylinder for a semaphore signal. The cylinder head 3 with its bracket is fastened to the support at 15. To this is clamped the valve magnet, B, and the pin valve. The cylinder, 1, and the bottom head, 2, are bolted to the main head as shown. Piston 4, moving in the cylinder, is forced down by the admission of compressed air at the top and motion is transmitted to the signal by means of the piston rod 9. This is connected to the "up and down rod" of the signal through a balance lever (Figs. 454-455). The piston rod is secured to the piston by a universal ball and socket joint, and disk 8, which is screwed into the piston, forms the lower portion of this joint. Washer 11 rests on the bottom cylinder head and keeps out dirt. When compressed air is admitted to the chamber C (Fig. 457), it passes through the diagonally arranged port N, to the space above the piston and forces the piston down, clearing the signal. When the magnet at B is de-energized, the air is shut off and chamber C is connected to atmosphere through D; the air in the cylinder

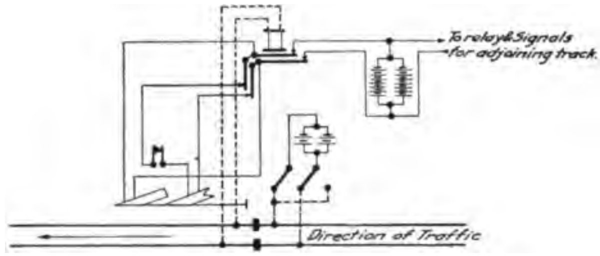


Fig. 461. Wiring for Electro-pneumatic Automatic Block Signal; Distant Signals Controlled by Polarized Track Circuits; Primary Battery. Pennsylvania Railroad.

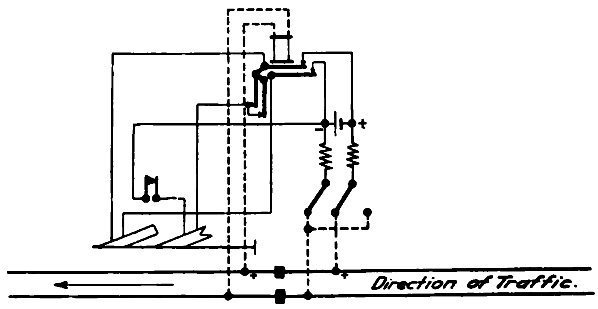


Fig. 462. Same as Fig. 461, but with Storage Battery in place of Primary.

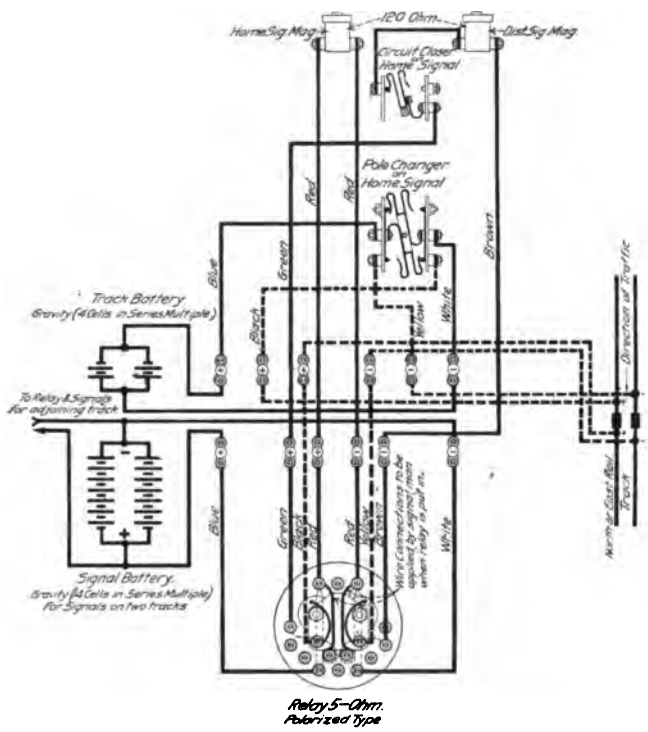


Fig. 463. Details of Fig. 461.

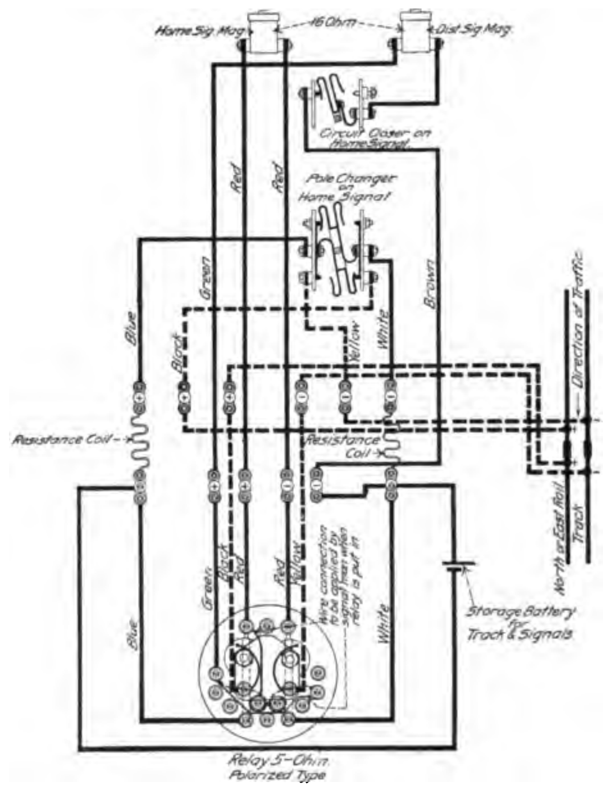


Fig. 464. Details of Fig. 462.

above the piston escapes, allowing it to assume its normal position, as shown, putting the signal in the stop position. This it does by gravity.

In Figs. 459 and 460 is shown an electro-pneumatic mechanism for operating a three-position semaphore. It consists essentially of two of the ordinary two-arm mechanisms superimposed one upon the other. The upper cylinder is shorter than the lower. The piston rod of the upper cylinder rests on top of but is not connected to the piston of the lower cylinder. The upper cylinder is used to move the signal through the first half of its stroke, that is from stop to caution, and the second half is accomplished by the action in the lower cylinder, the piston of which moves away from the upper piston rod. This rod acts as a stop when the signal is to be returned from the clear to the middle or caution position.

Names of Parts of Hall Electro-Gas Two Arm Signal Mechanism, Figs. 447-449.

1 *Cylinder*
2 *Piston*
3 *Cylinder Packing*
4 *Operating Rod (Cylinder Rod)*
5 *Pressure Gage*
6 *Regulator*
7 *Cut-off Lever, L. H.*
8 *Cut-off Lever, R. H.*
9 *Gas Valve, L. H.*
10 *Gas Valve, R. H.*
11 *Clutch Lever, L. H.*
12 *Clutch Lever, R. H.*
13 *Circuit Closing Rod*
14 *Circuit Closing Rod Spring*
15 *Circuit Closer*
16 *Valve Magnet Coils*
17 *Valve Magnet Armature*
18 *Valve Connector*
19 *Valve Lever*
20 *Valve Lever Adjusting Link*
21 *Frame*
22 *Cut-off Lever Pawl*
23 *Clutch Casting*
24 *Buffer Lever Roller*
25 *Cut-off Lever Roller*
26 *Clutch Casting Latch*
27 *Tank and Regulator Connection*
28 *Expansion Chamber Connection*
29 *Expansion Chamber*
30 *Cylinder Connection*
31 *Signal Rod Clamp*
32 *Clutch Casting Guide Rod*
33 *Clutch Casting Catch*
34 *Gage Connection*
35 *Valve Magnet Cover*
36 *Clutch Lever Shaft Support*

Fig. 465. The Blake Despatcher's Signal; Stop Position.

Fig. 466. Blake Signal; Clear Position.

Fig. 467. Blake Signal, with Oil Lamp.

Fig. 468. Despatcher's Desk; Blake Despatcher's Signal.

Fig. 469. Blake Signal, with Oil Lamp; Stop Position.

THE BLAKE SIGNAL

This is a non-automatic signal appartus by which a number of signals at different points along a railroad are made subject to the control of the despatcher at a central point. He is able to set in the stop position a semaphore of standard size, and by a selective apparatus he controls a number of signals by means of a single wire. The system is used on electric railroads where cars are required to stop at signals, the conductor then inquiring by telephone for orders. The selection is obtained accurately by means of the principle that the time of vibration of a pendulum varies with its length. A No. 10 bare iron wire is used on a line controlling a series of 15 signals.

When the despatcher wishes, for example, to set signal No. 9 he inserts a plug in hole No. 9 on his desk and thereby releases pendulum No. 9 in the desk and also connects the line with the source of the electric current. As the pendulum in the despatcher's desk swings it opens and closes the circuit, sending impulses over the line synchronous with its vibration. At the end of ten seconds the pendulum at signal No. 9 swings through an arc wide enough to trip a lock and drop the semaphore arm to the stop position. (It is turned upward to indicate proceed). As soon as the semaphore arm has reached the horizontal position it throws an interrupted ground on the line at that point, which causes an additional amount of current to flow through the relay on the despatcher's desk, causing it to draw up in unison with the swing of the pendulum; thus the despatcher receives a positive indication of the semaphore arm being set at "stop.'

When the car or train has arrived at this point and communicated with the despatcher by telephone, the despatcher withdraws his plug and directs the conductor to clear the signal. This the conductor does by pulling a cord; and the signal arm on completing its stroke is locked in the clear position, subject to the despatcher's control as before.

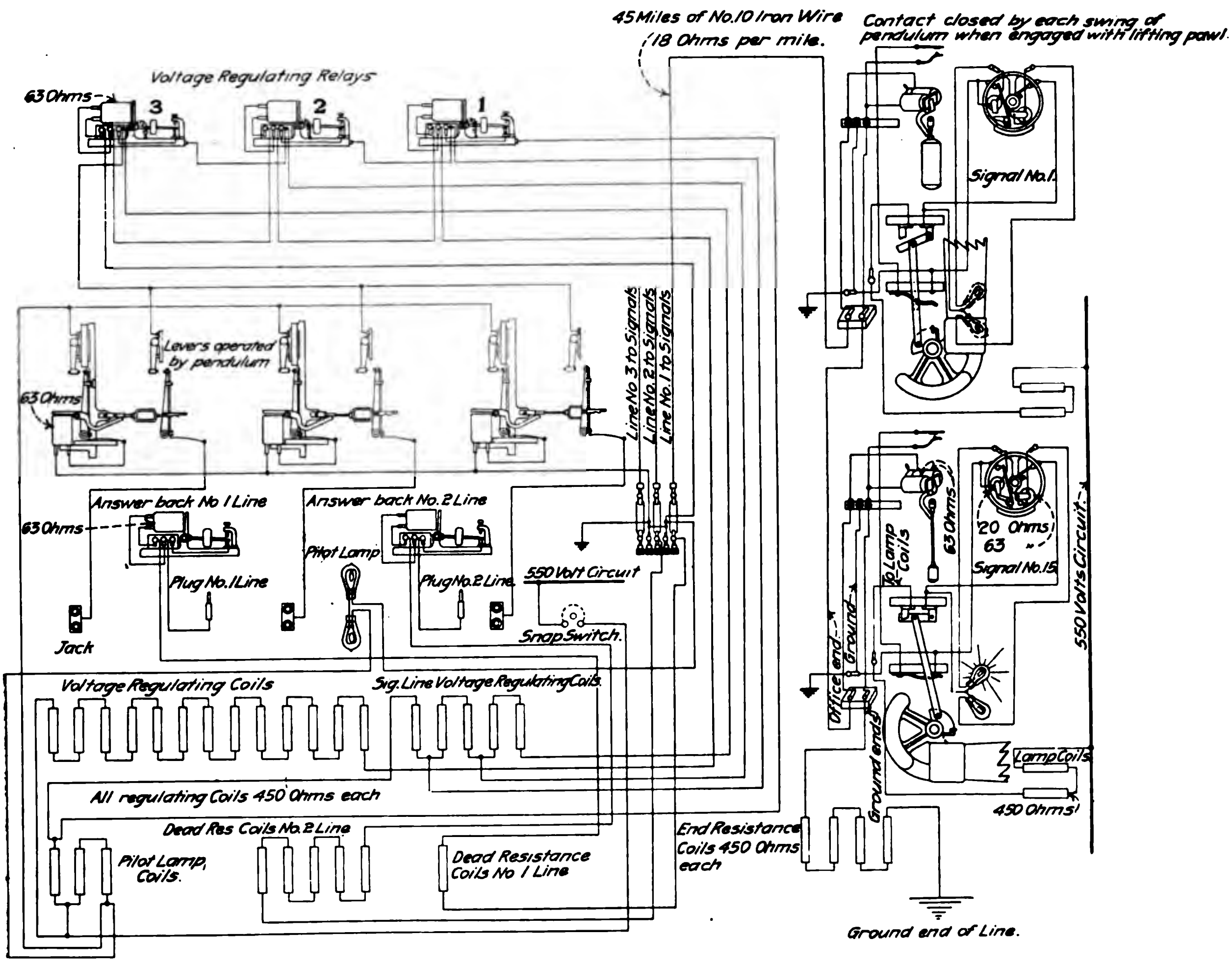


Fig. 470. Arrangement of Circuits for Blake Despatcher's Signal.

Fig. 471. "United States" Electric Block Signal.

Fig. 472. "United States" Electric Block Signal; Interior of Signal Box.

Fig. 473. Relay Controlling "United States" Electric Block Signal.

In the United States Company's system of signaling on single track sections of trolley roads, a signal box (Figs. 471-473) and an automatic trolley switch are placed at each end of the block. The signal box is placed about 100 ft. in advance of the trolley switch so as to be seen easily by the motorman as his car passes under the trolley switch. A car entering the block operates this trolley switch, lighting a white or green signal in the box directly in front of it, and a red signal, in series with it, in the box at the distant end of the block. A red signal always shows an approaching car, a green or white a receding one, while the block is clear only when the signal shows a green or white signal directly as the car passes the trolley switch. This system does not depend on the continuity of a lamp circuit for its protection to cars. Should the lamps burn out after being lighted, the "semaphores" would still remain set, but in case no "semaphores" were used it would still be impossible to get a clear signal to enter the block in either direction on account of the relay (Fig. 473) being mechanically locked. Failure of power from the trolley wire only puts out the signal until its return.

The relay contacts are made of spring phosphor bronze and are interchangeable and easily replaced. The relay levers are made of aluminum in order to reduce the inertia of the moving parts. They are very light, yet strong, and require a contact of less than .017 second duration to operate them. The relay is connected to the box by means of eight spring contacts located on the under side of the relay base which is one piece of heavy slate. These springs engage with a set of contact points in the top of the main part of the box, and when the relay is in place are separated from each other and surrounded by fiber barriers. This reduces to a minimum the liability of lightning jumping from one terminal to another.

The relay magnets are large and strong. They will operate on any line voltage over 160. The cores and pole pieces are made of soft Norway iron annealed and blued. All the magnet coils are wound on fiber spools with No. 23 double cotton covered wire, and varnished with three coats of heavy shellac, making them practically waterproof.

The vital point in every system of this kind is that the signal,

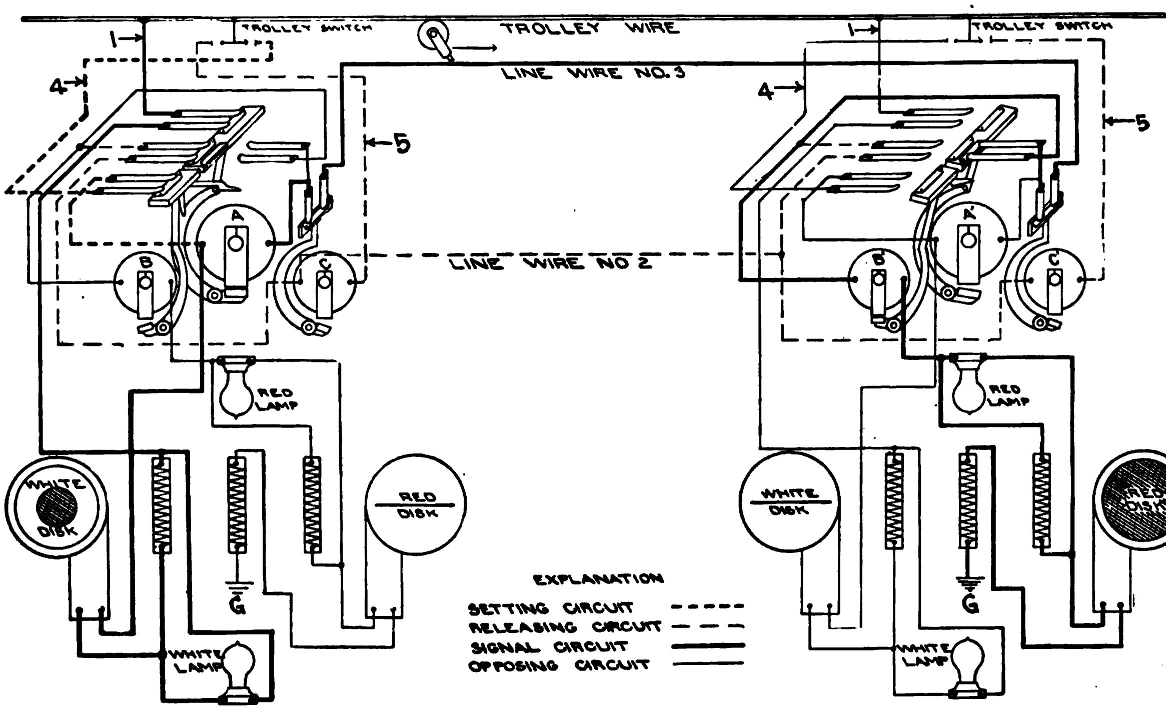


Fig. 474. Diagram of Circuits Used With the "United States" Electric Block Signal.

once having been set in the stop position, should remain so regardless of all other conditions until released by a car leaving the block. This is accomplished by using a small mechanical lock which holds the operating lever in a closed position until unlocked by a car leaving the block.

Resistance tubes are used, the total resistance of the box being contained in three or four tubes. Two of these are used as shunts for the "semaphores" and contain 530 ohms each. The others are used as terminal resistances. These tubes are held in place by a clamp at each end, and it is only necessary to loosen two screws to remove them in case it is necessary to make a renewal. By insulating the parts by barriers, the effect of lightning and resultant arc of the power current has been reduced to a minimum. The "semaphores" are housed in a separate casting which is fastened to the main signal box by means of two hinges on the rear and a stop pin and cotter on the front edge. They are easily removed from the box by simply lifting off the hinges. The disk, which is eight inches in diameter and pivoted horizontally between two glass windows, is made of sheet metal painted and varnished; one red and one green or white. It is operated by a large magnet placed in the lower part of the housing, there being no mechanical connection between them and the main signal box. They work independently of the lights. The wire used is No. 12 white fireproof covered, and is all form bent. Five two amp. fuses mounted on two porcelain bases are used. Each circuit, with the exception of the setting circuit, No. 4, being fused. When the signal circuit is in operation, it contains four fuses in series, thus giving four-fold protection against burn-outs. The signals use the ordinary 16 c. p. 110-120 volt lamp. The lenses are five inches in diameter and the glasses are "solid color." The location of wires, contacts and fuses is shown in Fig. 472.

In the diagram (Fig. 474) is shown the path of the current through the magnets and signals, and the manner in which the signal is set and released. When the car represented by the trolley wheel entered the block it closed the right-hand contacts of the trolley switch for an instant, allowing the current to flow over the circuit represented by heavy dashes (4), through magnet A and over line wire No. 3, through the other signal, to the ground. The path taken from magnet A, is shown by the heavy full line. Magnet A, upon being energized, throws over its contact lever, disconnecting the ground at this, the setting end, and cutting in a permanent feed from the trolley wire to take the place of the switch contact, which opens immediately after the car passes. This permanent feed also throws the white (or green) lamp and disk into the signaling circuit, and it is their appearance which shows that the red signal is displayed at the opposite end. The other set of contacts closed by this magnet complete a circuit which starts in the outside contacts of both trolley switches. It will be seen upon looking at the diagram that the signaling circuit leads through magnet B′ at the other end, opening a pair of contacts known as the Non-Interference Device. These contacts open the setting circuit from the trolley switch and prevent a car trying to enter from the opposite end, locking up the lever to magnet A′, which would connect both ends of the signaling circuit to the trolley wire, making a dead signal until some car passed out of the block. The circuit indicated by light dashes (5) is known as the releasing circuit. When the car leaves the block, going in the direction shown by the wheel, it closses the right-hand contacts in the right-hand switch, thus allowing current to flow through magnet C′, which breaks the main signaling circuit, and also through magnet B, which unlocks the lever of magnet A. The magnet A, now being de-energized and the lock open, allows the lever to fall back and the system is in its normal position of no car in the block.

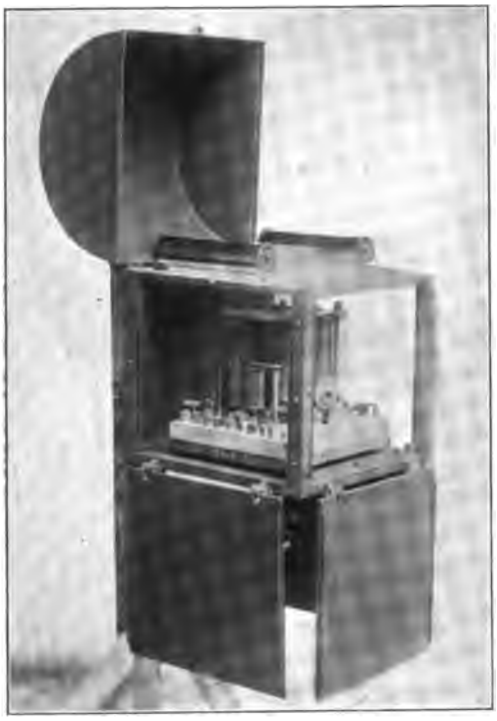


Fig. 475. Signal Controller in Case. Eureka Electric Signal.

Fig. 476. Eureka Electric Signal. The upper circular opening is closed by shutters.

Fig. 477. Signal Controller. Eureka Electric Signal.

Fig. 478. Trolley Contact Maker. Eureka Electric Signal.

THE EUREKA ELECTRIC SIGNAL.

Two main controllers (Fig. 477) are used for each section of track. These do not operate in synchronism. When one or more cars enter a section the controller at the end entered operates, setting the signals to stop and displaying red at the other end. Cars going through the block in the opposite direction are protected by the operation of the other controller. Should cars attempt to enter the block at opposite ends at the same time, both controllers would operate to counteract each other and thus lock at stop, the "home" signal, Fig. 476, at each end of the block. At each end of a block the upper is the "home" and the lower the "distant" signal. A block is occupied when both are clear at one end and at stop at the other, the movement of the car or cars being toward the signal-indicating stop. A block is unoccupied when at both ends of it, the upper signals are at stop and the lower clear. When the signals are in this position a car may enter a block at either end, provided the "home" goes to clear when the contact-maker has been passed. If the "home" goes to clear the distant at the far end of the block will be displayed against approaching cars, and the "home" at that end will be locked at stop, so that the car in the block will be protected by two signals, blocking cars coming from the opposite direction. Additional cars may follow the first car into the block. In such case the signals will remain as set by the first car, but in the "home" the lights will change with each car taking the block. When two cars attempt to enter a block at opposite ends at the same time, neither can clear the "home;" or if there is a difference in the time of such attempt, the first car in the block will set the "home" at its end and lock the other "home" at stop, and at the same time set the "distant" at the far end of the block. Should a car go into a block against stop signals, both "homes" will be set at stop before the overrunning car can pass that at its end, and will remain so until one of the cars backs out of the block, when the system will be automatically set to protect the car remaining in the block.

The signal line, extending from end to end of the block, passes across the base of the controller through switches A, D, C and F, and not through the magnets. This signal line, when the block is not occupied, is grounded at both ends through the controllers by means of switch D and wiring 8 to the rail. Between each controller and that ground the "distants" are placed, through the magnets of which and through the lamps therein the current flows to set these signals. By means of switches A and wire 1, in which the

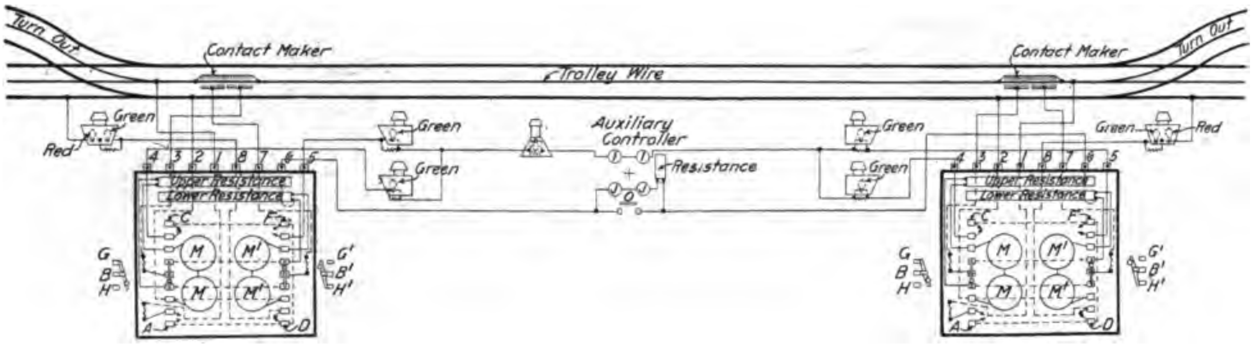


Fig. 479. Signal Control Circuits. Eureka Automatic Electric Signal.

magnets operating the "homes" are placed, the signal line is connected to the source of power. From the other side of each controller two switches, C and F, one open when the other is closed in alternation, a loop extends some distance into the block, in each branch of which a lamp is wired, both located in the "home" signal, one aglow when the other is not in alternation, by means of the switches mentioned. When both controllers are set to ground, switches D being closed, no current can flow and there can be no operation; and when both controllers are operated to connect the signal line to the source of power, switches A being close and D open, no current can flow and there can be no operation. Only when one controller is operated to close switch A, connecting in that controller the signal circuit through wiring 1 to source of power, leaving the ground through the other controller intact, can the "home" signal, normally at stop, be cleared and the "distant" put "on."

The diagram of wiring shows two contact makers (Fig. 478), the simpler method of installation; but where spring track-switches are used, which can not be hand operated, it is preferable to use four contact makers, two at each end of the block, one placed over each branch of the siding. The use of four contact makers will enable operation of signals before passing through the track switch, which if once passed requires the car to back around the turnout in case it cannot go through the block, as may be necessary for various reasons. The "direction switches" are normally closed, the one marked GBH when B and G are bridged, and the other marked G'B'H' when B' and H' are bridged, operation to bridge from B to H being effected by energizing of magnets MM, and from B' to G' by magnets M'M'. When a car enters a block the trolley wheel makes contact so that current flows from first half of contact maker through wire 7 to fuse block, thence through closed "direction switch" from B' to H', across base of controller through block H of other "direction switch," thence through upper resistance and magnets MM to ground through wire 2. This cuts the signal line into feed connection and also sets the "direction switch" from BG to BH, so that when the trolley wheel reaches the second half of contact maker, current will flow through wire 3 to fuse block, thence through "direction switch" from B to H, and continue through upper resistance and magnets MM, causing current to flow from entire length of contact maker through magnets MM. Additional cars going into the block repeat this operation. When a car has passed through the block, upon leaving it the trolley wheel first makes contact so that current flows from the "finger plate" in connection with wire 3 to fuse block, thence through "direction switch" from B to G and across base of controller through G' to lower resistance, where the current divides, a portion going through that resistance and magnets M'M' to ground, across base of controller through wire 2, thus setting, by means of magnets M'M' "direction switch" from B'H' to B'G', so that current, when second half of contact maker is reached, will flow through "direction switch" from B' to G' by way of wire 7 and fuse block, lower resistance, and magnets M'M' to ground, the portion of current from entire contact maker diverted at lower resistance, not yet traced, passing out by wire 6 to other end of block through switch O of auxiliary controller, and in by wire 6 to and through lower resistance at that end; thence direct through magnets M'M' to ground, as previously explained, thus operating magnets M'M' to cut out the signal line from feed connection. This holds good for cars passing through the block from either end. The current coming in by wire 6 cannot flow along the wire with which it connects at lower resistance because that circuit will be open at the contact maker.

When a car has entered the block and the signal line has been cut into the feed connection, the current flowing through it illuminates the lamps and energizes magnets 11 of the auxiliary controller to close switch O. This switch thus always closes when cars enter only at one end of the block and pass through and out of it at the other end. Should cars enter at both ends—at one end in defiance of the signals or by over-running, and thus connect the signal line to the source of current at each of its ends—no current can flow through magnets 11, and switch O will be open. Thus when cars, for any reason, enter at both ends of the block, the open switch O, as a result, leaves no closed path from end to end, and when the car wrongfully in the block backs out of it, current from contact maker at that end can only operate the nearby controller and not the distant one, thus again establishing a ground connection and a flow of current through the signal line. The signals are then set; the red signal against itself, or, properly, for the car coming through the block. But when a car passes through the block without being interfered with by cars at the end which it approaches, it will have a closed circuit through switch O back to the controller, to permit current to flow from the contact maker it is passing to reverse the operation and set back that controller to disconnect the signal line from source of power and connect it to ground.

The function of magnets JJ is to hold switch O open when magnets 11 are energized to close it, as occurs immediately when the trolley wheel makes contact with the finger plates of the contact-maker, and it holds it open until the trolley wheel has passed through the entire length of the finger plates. These magnets JJ receive only sufficient current through the high resistance in series with them to energize them to hold open switch O, the current being too feeble to operate the main controller through which it continues to ground.

The wiring diagram shows all lamps with resistances in shunt around them. Thus if a lamp burns out, the closed path around it permits enough current to flow to keep the other lamps in series aglow and the signals in proper operation. By use of resistances, therefore, the operation of the signals is independent of the lamps, and burnt out lamps are easily located.

THE NACHOD AUTOMATIC SIGNAL.

The Nachod Automatic Signal made by the United States Engineering Company, is intended for single track electric roads operating cars in both directions and having turnouts at meeting points, of the through type and not stub end; also for double track roads having stretches of single track where one end of the block is not visible from the other. Its object is to prevent butting collisions by indicating automatically both the presence and direction of a car on a single track block by a system of signals at the turnouts.

The power to operate the signal is taken from the line, and its operation is dependent on the car in the block having passed certain actuating points. The equipment, in duplicate at each end of the block, consists of a signal box containing lamps as indicators and the intermediate apparatus or relay. The actuating device consists of four overhead trolley switches, one located in each branch of the wire at the entrance of the block. If the cars keep to the right in passing through the turnouts, the right hand switch at the entering end will be an "on" switch, while the right hand switch at the leaving end will be an "off" switch. The signal boxes are connected by a single overhead wire running the length of the block. A green light indicates clear, and this light is burning at each station in a local circuit at all times when the block of single track is not occupied. A motorman of a car about to enter the block understands by the green light that the block is clear, runs under the overhead trolley switch, and sees the green light change to white. This gives him positive evidence that the red light is burning at the other end, and that he is thereby protected against a car entering from that end. These lights burn in series through the signal line wire. When his car leaves the block, in running under the corresponding "off" switch it clears the signals by extinguishing the red and white lights and lighting the green. Another car which may have been held by the red light, may now enter the block similarly, setting the signals oppositely, and passing out, will clear them again. A motorman of a following car approaching the block before the first has left it, will see the white light, which indicates that the block is not clear, but has at least one car on it going in the same direction. The second car will therefore enter the block, producing no change in the signals except a "blinking" of the white light as it runs under the trolley switch, indicating registration; and so on for each successive car that follows into that block.

During all the time the block is occupied, the red light burns at

Fig. 480. Nachod Automatic Signal. United States Engineering Company.

Fig. 481. Controlling Mechanism. Nachod Automatic Signal.

Fig. 481a.

Fig. 481b.

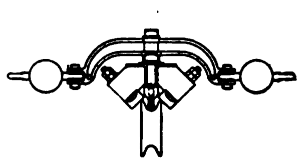


Fig. 481c.

Trolley Contacts for Nachod Automatic Signal.

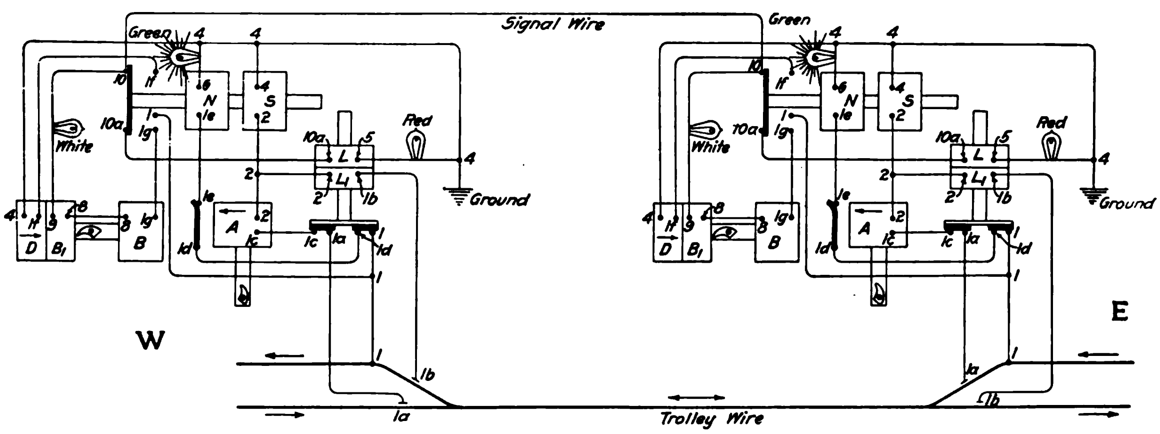


Fig. 482. Arrangement of Circuits for Nachod Automatic Signal.

the far end, so that the signal system maintains an absolute block at the red end, and a permissive signal at the white end. When these cars leave the block, one by one, the lights are unchanged until the last one leaves, when the signals are cleared and the green lights reappear. Fifteen cars may enter the block in succession and occupy it at once, or they may be continuously entering and leaving, and they will all be protected. Hence the following rules:

1. The first car must not pass the signal box to enter the block unless the white light is burning.

2. Following cars must not enter the block unless the white light blinks on passing the switch.

Just as soon as the red lamp lights at the distant station, the "on" switch at that end is "dead," or cut out of operation. If the motorman should enter the block against this red light and a collision result thereby, the signals will not have been changed, and the responsibility for the accident will be placed. The motorman's knowledge of the fact that he cannot destroy the evidence of his passing the red light, will restrain him from attempting to disobey the signal set. This therefore makes for safety; for, on the other hand, should he be able to extinguish the signals, and an accident result, the opportunity that would arise for a dispute as to which had the right of way might lead him to take a chance.

Should two cars be trying for the block from opposite ends and one of them run under the switch an instant before the other, the first motorman, seeing the white light appear, would go ahead; and the second, seeing the red light flash against him, not being able to stop before running over the switch, would have to pass it and back over it again to wait. In doing this, that "on" switch being dead, the second car would not affect the signals in any way. Should two cars trying for the block strike the switches at the same instant, the lights at both ends would show green, indicating an unset signal. Both cars would therefore back to the trolley switch

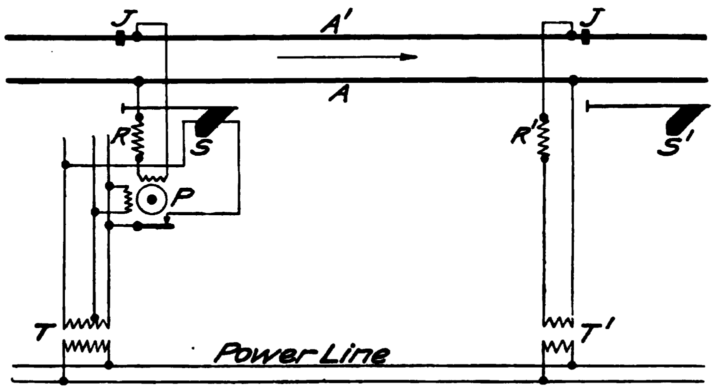


Fig. 483. Home Signal Controlled by Simple Alternating Current Track Circuit, with Polyphase Relay; One Rail Used Exclusively for Signal Track Circuit.

and the first one arriving, would set the signals, holding up the other car and cutting that "on" switch out of operation. If a motorman should enter a block, set the signals, and leave by any except the corresponding "off" switch, he can clear the signals by opening and closing the hand clearing switch (not shown) installed near the signal box, the same number of times he has passed the "on" switch. Should the car enter the block and back off the other track without having passed through the block, the signals may be automatically cleared without using the hand switch by running a second line wire (not shown) in case the frequency of this operation justifies the expense. No false indication of safety can be produced by the burning out of any signal lamp, and since they are connected in shunt their failure will not affect the operation of the relay. They act only as indicators of the relay positions. The signals may be operated as a "closed block" system for work cars by the entering work car leaving the hand clearing switch open, in which condition the signals will remain at green, and no white light can be obtained from either end. The work car must, however, back out the same end to close the hand switch and leave the signals for normal operation.

The type of trolley switch used, Figs. 481a-481c, has no moving-

1e-1d is the revolving switch, which A opens and D closes by pawls. Positions shown are for "clear" block. In the clear block both ends of the signal wire are grounded through a red lamp (10-10a-5-4-ground). In the local circuit of the clearing coil (1-1d-1e-6-4-ground) is a green light and the revolving switch 1e-1d, which in the clear block is closed. In each relay there is a main two-way switch, whose chief function is to transfer that end of the signal wire, either to trolley or ground. It is operated by the setting coil S, which connects the signal wire at the entering end to trolley through a white light as the first car enters, and by the clearing coil N, which transfers it to ground through a red lamp when the last car leaves.

The first entering car at E forms a temporary circuit, 1-1a-1c-2-4-ground, through coils A and S. This opens the local clearing circuit at the revolving switch and at the same time throws the two-way switch to trolley, setting the signals and causing a current to flow from the trolley, through the white light, signal wire, red light at distant end to ground. (1-1g-8-9-10...........10'-10a'-5'-4'-ground). An opposing coil D is simultaneously energized by the two-way switch through a local circuit (1-1f-4-ground), tending to close the revolving switch again, but prevented therefrom by coils B B, which

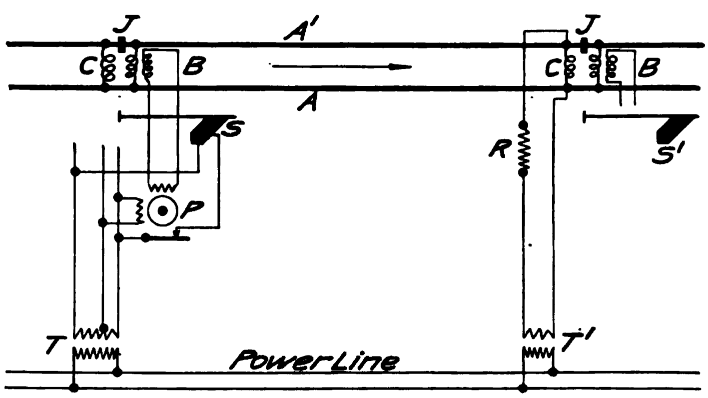


Fig. 484. Signals Controlled by Alternating Current Track Circuits; "Ironless" Reactance Bonds; Both Rails Used for Propulsion Current.

parts and operates independently of the position of the controller handle on the car. A light angle iron frame supports at its ends the insulated contact strips which are inclined to each other, one strip connecting to trolley wire, the other to signal box. The wheel merely bridges them, the trolley wire being raised above its path. The contact strips are flexible and are formed so as to receive the trolley wheel without shock.

The signal box, Fig. 480, is a cast iron case, the upper part containing the lamps, lenses and incoming leads. The relay, Fig. 481, and the enclosing oil tank, which forms the lower part, hang from this separately, suspended by studs. The complete immersion of the relay under oil keeps the coils cool, suppressing all arcing at the contacts, lubricates the moving parts continuously, and increases the insulation. The relay is constructed for quick operation, an extremely short time of contact being sufficient to operate the signals. It consists of four plungers operated by magnet coils carrying insulated metal contacts to change the connections between stationary fingers. Fig. 482 shows a simplified diagram of connections. With no current in the coils, vertical armatures drop and horizontal ones remain as left. Coils D and B are equal and opposite in polarity.

are excited when the signals are set. When the car leaves the block at W it breaks the latter circuit at the leaving end for an instant, permitting the opposing coil to act and clear the signals as follows: It makes a temporary circuit 1-1b-2-4-ground through coils L and S. The plunger of L, being raised, S draws its plunger not further than the mid-position, opening all its contacts. There being then no current in B B, D closes the local clearing circuit at the revolving switch, the clearing magnet N operating the two-way switch and restoring the entering end of the signal wire to ground. Both ends of this wire are now grounded, the white and red lamps extinguished and the green lights burning in the local clearing circuits.

The revolving or step by step switch consists of a finger that lies over a contact point when the signals are clear. Each entering car revolves the point one notch or step ahead, and successive cars further open the switch step by step. Each leaving car revolves the finger one step, so as to follow the point. When the same number of cars have left as have entered—and not until then—finger and point being in the same relative position as at first, that is in contact, the clearing circuit is closed.

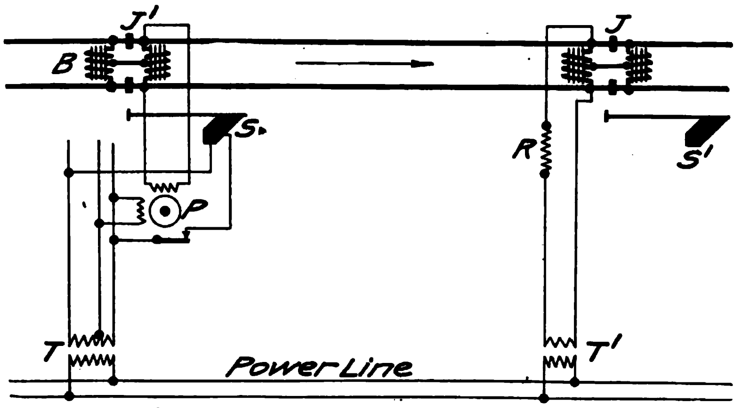


Fig. 485. Signals Controlled by A. C. Track Circuits, Iron Core Reactance Bond; Both Rails Used for Propulsion Current.

THE ALTERNATING CURRENT TRACK CIRCUIT.

In the signaling of roads employing steam as the motive power the track circuit is comparatively simple (Fig. 371). When, however, the rails are required to carry the heavy currents called for by electric traction, the track circuit problem becomes more difficult.

First: Because the rails must be made electrically continuous throughout to serve as a return for the propulsion current and at the same time must be divided into electrically insulated sections as far as signaling current is concerned.

Second: Because the traction current flowing in the rails would tend falsely to operate the track relays were they of the usual direct current type; hence, the necessity of employing relays which are unaffected by the traction currents and supplying a signaling current of the right character to operate them (see description of Boston Elevated track circuits, Figs. 548-553).

Third: Because for traction purposes cross-bonding between tracks is necessary at frequent intervals, thus influencing the arrangement of track circuits.

Figs. 483, 484, 486 and 541 show three types of track circuits, which fulfil the requirements imposed by electric traction. In all of these, alternating current is used for signaling purposes. The

On account of the fact that alternating current is used for signaling and that either one or both of the rails may be used for the propulsion current return, the circuits are known as "Single Rail A. C. Track Circuits," or "Double Rail A. C. Track Circuits."

Fig. 483 shows the "single rail" circuit, which is the simplest form of A. C. track circuit, and is only used where it is permissible to give up one of the rails for signaling purposes only. It is best adapted to roads employing direct current for propulsion. The rail A is continuous throughout and is used as a return for the traction current. Rail A' is insulated at the joints J-J, and is used only for the signaling current. P is an alternating current relay of the two-phase type described above. When both windings are energized the motor revolves, and being geared to the contact closes it, the contact acting as a stop to the movement of the armature, which now ceases to turn, but bears against the contact, holding it closed. The signal S (using current from the transformer T) operates as already described in connection with Fig. 371.

When a train enters the track circuit the current from transformer T' is shunted out of the relay, as already described in the ordinary direct current track circuit and, although current from

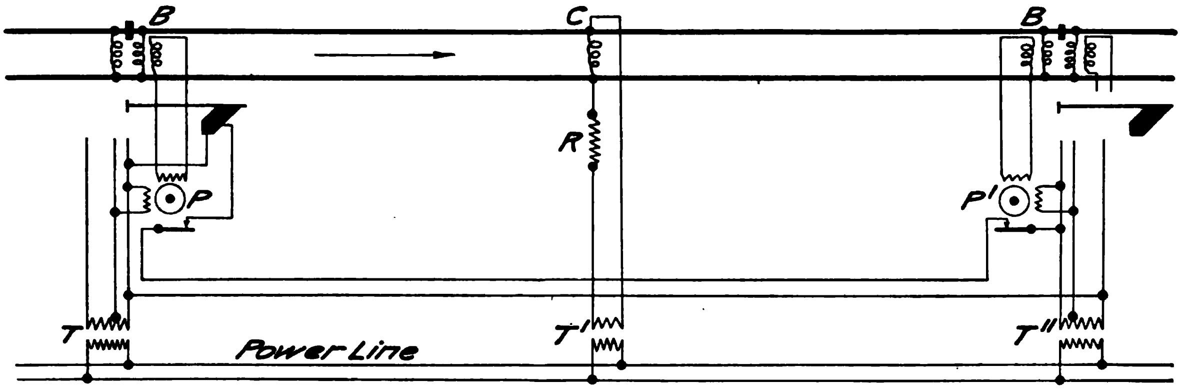


Fig. 486. Same as Fig. 484, Except that Current is Supplied to the Track Circuit in the Middle and Two Track Relays are Used.

track relay contacts being operated by a small two-phase induction motor, one winding of which is energized through the track rails and the other winding direct from the power line. This relay is not affected by direct current, no matter what frequency, within reasonable limits, is used for signaling and is not affected by alternating current if a frequency distinctively different from that of the traction current is used. For in a two-phase induction motor, if the phase in one set of field coils varies greatly from that in the other, the motor will not operate. As both sets of fields in the two-phase induction motor relay are fed from transformers on the same single phase power line, some agency must be provided to produce different angles of lag in the two secondary circuits, otherwise the relay would not act. Such agency exists in the different apparent resistances of the line circuit and the track rails. Also in inductive and impeding effects of the rails and bonds. It is not necessary, however, to use two-phase motor relays. Single-phase induction relays, Figs. 530-534, give good results. But where the track circuit is long and leakage heavy it is better to use two-phase relays, as they have a good torque with a small current from the track. They are more expensive, however, than single-phase relays and add some complication to the wiring.

the transformer T still continues to flow through one winding, the motor loses its torque, the armature is revolved in reverse direction by gravity and the relay contact opens.

R and R' are resistances so proportioned that the drop in potential in rail A, caused by the flow of traction current, will not cause injurious currents to flow through the relay P, or the secondary at the track transformer T'. (See Boston Elevated description.) The resistance R' also prevents an excessive flow of current from transformer T', when a train is standing at the transformer. These resistances are of the non-inductive type. They are made of cast-iron grids (Figs. 528-529). It can readily be seen from their form that current passing through them produces no magnetic effects. The grids are mounted on two or more rods, which are provided with the necessary insulation and can be built up to any desired resistance. On roads using direct current for propulsion where traffic is heavy it has also been found desirable to use a small impedance coil or "ironless" reactance bond (Figs. 488a and 527) connected in multiple with the track winding of the relay. This coil being of very low ohmic resistance assists the grid R, in keeping direct current out of the relay.

T and T' are stepdown transformers, which reduce the voltage

Letters Refer to List of Names of Parts Below.

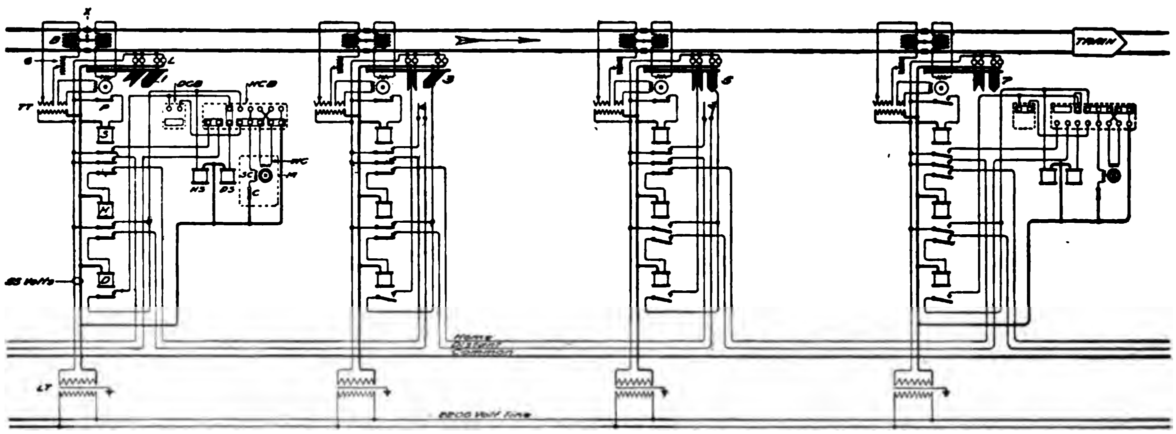


Fig. 487. Arrangement of Circuits for Alternating Current Automatic Signals; Full Block Overlap. Electric Zone, New York Central & Hudson River.

Names of Parts of Fig. 487.

B *Reactance Bond*
C *Centrifugal Cut-out*
D *Distant Motor Control Relay*
D C B *Circuit Controller on Distant Signal*
D S *Distant Slot*
G *Adjustable Grid Resistance*
H *Home Motor Control Relay*
H C B *Circuit Controller on Home Signal*
H S *Home Slot*
L *Electric Lights*
L T *Line Transformer*
M *Induction Motor ("Squirrel Cage" Type)*
P *"Polyphase" Track Relay*
S *Secondary Track Relay*
S C *Starting Coil of Motor*
T T *Track Transformer*
W C *Working Coil of Motor*
X *Connection between Reactance Coils for Cross Bonding*

from the power line to that required for track circuit and other purposes. Cross-bonding for traction purposes may be made at any point on the continuous rail A.

Fig. 484 shows a type of A. C. track circuit in which both rails are retained for propulsion purposes and which permits of cross-bonding from one rail of either track to one rail of the other track at any point desired. It is best adapted to installations where the track circuits are very long and where the traffic and consequently the propulsion current return is light. It is applicable only to roads using direct currents for propulsion. Rail A is continuous throughout and rail A' is divided by the insulated joints J J. Both rails are available for the propulsion current; rail A, because it is continuous, and rail A', because it is made continuous by the "transformer bond" B and "reactance bond" C, which are of very low ohmic resistance and have a current capacity of half that per track.

Fig. 488. Track Transformer for Single Rail Track Circuits. Electric Zone, New York Central & Hudson River.

The "transformer bond" B has a secondary winding, as shown, which is connected directly to and energizes one of the windings of relay P. If the relay winding in question were connected directly to the rails, as shown in Fig. 483, an excessive amount of direct current would flow through it, owing to the low resistance of the relay winding and the drop of potential in the main coil of bond B, due to the flow of traction current; hence, the secondary winding on this bond. (See Boston Elevated description, Fig. 552.)

Reactance bond C, while forming a path of low resistance for the propulsion current, at the same time offers an impedance to the passage of the alternating current from rail to rail, due to self-induction, whereby a portion of the alternating current is caused to flow along the rails and through the transformer bond B, inducing sufficient current in the secondary coil of that bond to operate the relay.

The track relay P and its operation is the same as described for Fig. 483, and the transformers and resistance grids are of the same general character. With good rock ballast track circuits of this type, up to 9,000 feet in length, have been operated satisfactorily. It is, however, possible to operate with equal satisfaction track circuits of twice this length by placing the energy transformer T' at the center of the section and using transformer bonds B and track relays P at both ends, the signal control circuit being carried through the contacts of both of these

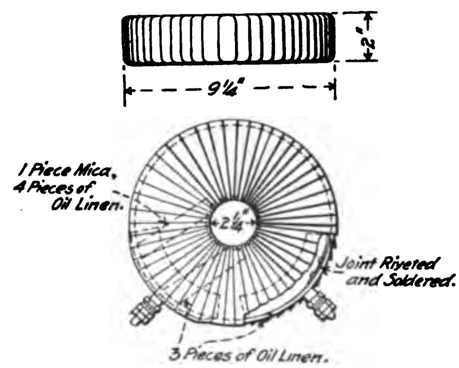


Fig. 488a. Ironless Reactance Bond Used with Single-Rail A. C. Track Circuits.

In Fig. 488a the coil consists of 135 ft. (about 92 turns) of soft copper, .025" x 1⁹/₁₆", weighing 23 lbs., insulated with Tarbon paper and impregnated after winding. Resistance .08 ohms, impedance, .128 apparent ohms.

Fig. 489. Track Transformer Coil and Case; for Double Rail Track Circuits.

Fig. 490. Track Transformer with Cover Removed; for Double Rail Track Circuits.

VOLTAGES

WITH "A" CONNECTED TO "1" & 50 VOLTS ON PRIMARY, TRACK VOLTAGES WILL BE

VOLTAGE DESIRED	CONNECT LEAD "E" TO	CONNECT LEAD "F" TO	JUMPER FROM	JUMPER TO
0.45	7	8	NONE	
0.90	9	12	8	10
1.35	10	11	NONE	
1.85	11	12	NONE	
2.30	8	9	NONE	
2.75	7.	9	NONE	
3.25	10	12	NONE	
3.70	7	12	8	10
4.15	7	11	9	10
4.63	7	12	9	11
5.55	8	12	9	10
6.00	7	12	9	10

NOTE—TO INCREASE SECONDARY VOLTAGES 5 PER CENT.
CONNECT A TO 2. TO INCREASE 10 PER CENT.
CONNECT A TO 3.
ALWAYS CONNECT "B" TO 4. "C" TO 5 AND "D" TO 6.

Table of Voltages for Track Transformer, Figs. 489-491, Showing Connection Necessary to Obtain Various Voltages as Required by Local Conditions.

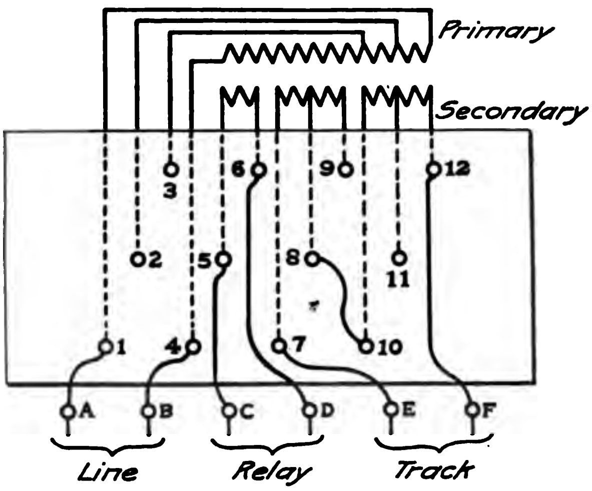


Fig. 491. Wiring Diagram of Track Transformer Figs. 489-490.

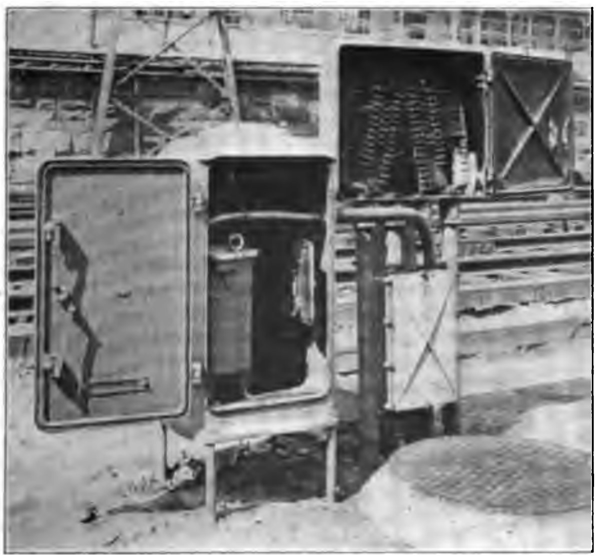


Fig. 492. Line Transformer in Case; Junction Boxes at Right. Electric Zone, New York Central & Hudson River.

relays in series, as shown in Fig. 486. If cross-bonding is required to the insulated rail at the center of the section, a reactance bond C would be connected across the rails as shown.

Fig. 485 shows another type of A. C. track circuit, in which both rails are retained for propulsion purposes, but in which cross-bonding to adjacent tracks can occur only at the ends of track circuits. This type of track circuit is especially adapted to roads where the traffic is very heavy and the blocks of medium lengths; and is applicable to either A. C. or D. C. traction. As shown, both rails are insulated at the signal locations by the points J and are made continuous as concerns the traction current by the iron core reactance bonds B. The bonds (Figs. 494, 495, 510, 511 and 547) consist of a few turns of very heavy copper, wound around a laminated iron core and so connected to the rails that the traction current in each rail flows through one-half the bond in such manner as to have no magnetic effect unless more current is flowing in one rail than the other, in which case there would be a tendency to saturate the iron core and thus reduce the reactance of the bond. This tendency is, however, limited by an air gap in the magnetic circuit. This difference of current is called *unbalancing*. This can be better understood if it is noted that propulsion current flows in the same direction in each rail. Therefore the bond is in effect two electro-magnets of equal strength wound on the same cores in opposition. Thus the magnetic effects due to direct current in one winding will neutralize that in the other unless more current should flow in one rail than in the other. If the iron core were continuous the effect of an unbalanced propulsion current would be to shift the neutral magnetic point along the core a distance proportional to the amount of unbalancing. For this reason the air gap is introduced in the magnetic circuit, and the wider the gap the less the neutral point will shift for a given amount of unbalancing because air is a poor conductor of magnetic lines of force compared with iron. But the wider the air gap is made the lower becomes the inductive effects of the iron (which is a maximum when the core is continuous), and the greater the leakage of alternating current across the rails, due to the impaired reactance.

This type of reactance bond does not require the use of a secondary coil for energizing the relay, as in the case of the transformer

bond B, Fig. 484, since in the iron core reactance bond the voltage drop in one-half of the coil neutralizes that in the other. Therefore, the relay can be connected directly to the rails, as shown in Fig. 485, without the chance of having excessive amounts of propulsion current flow through it. In the case of traction cross-bonding to adjacent tracks the connection for such bond to the rails may be made only at the point between bonds as shown at X, Fig. 487, and, therefore, the permissible length of such track circuits will be limited by the required frequency of cross-bonding. The size of the bond, for a given reactance, is dependent upon the amount of traction current to be carried and the amount of unbalancing to be taken care of.

Track circuits, as shown by Fig. 485, may be satisfactorily operated to a length of about 2,500 ft. and to a length of 5,000 ft. by applying the energy at the center of the section substantially as shown by Fig. 486. The track relay is the same as described, and the transformers and resistance grids of the same general character.

Aside from the track circuit, above described, the other devices incident to a complete signal system, such as the signals, signal operating batteries, line relays, method of control, etc., need be no different for electrified roads from those used on steam roads; but when it is considered that a power line must be strung the entire length of the system to supply the track circuits with energy, it becomes unnecessary to continue the use of batteries and other kinds of power, in addition, when the signal movements, line relays, lights, etc., can as well be designed to operate from alternating current, and thus have a system in which but one kind of power is used for all purposes, requiring but one set of generating apparatus and one power distribution system.

Such a system has been designed by the General Railway Signal Company and installed at the New York City terminal of the New

Fig. 493. Reactance Bonds in Place. Electric Zone, New York Central & Hudson River.

Fig. 494. Reactance Bond Complete (except Oil); Cover of Case Removed.

Fig. 495. Reactance Bond Removed from Case.

York Central & Hudson River Railroad, the lines being designated as the "Electric Zone."

The following is a description of this system, which will serve as an illustration of an automatic electric block signal system for a direct current electric road, in which alternating current is employed for the operation of the track circuits and all the signal devices.

The signals are of the two-arm, two position, semaphore type, with a full block overlap arranged on the normal clear principle, as shown by the circuit plan Fig. 487. The signals are spaced from 800 ft. to 3,200 ft. apart to conform to the condition of the grades, the allowable speeds at different points and the safe braking distance.

Twenty-five cycle, single-phase alternating current is used for the operation of the entire block signal system. It is normally obtained from the railroad company's 11,000-volt, 25-cycle bus-bars and stepped down, by means of static transformers, to 2,200 volts for distribution. As a reserve, in case of failure of the 11,000-volt power, motor generators are installed taking power from the railroad company's 650-volt storage battery. The switchboard circuits are arranged so that the transformer and motor generator can operate singly or in multiple, as desired.

There are eight substations arranged six miles apart varying in capacity from 60 to 100 k.w. In addition to the power required for the block system, these substations also supply the power for operating the battery, charging motor generator sets, signal lights, indicators, relays, etc., employed in the interlocking plants in the Electric Zone.

The transmission line is interrupted midway between adjacent substations so that normally each substation feeds both ways, being independent of its neighbor; this to avoid the need of keeping them in synchronism. In case of emergency, however, the transmission lines can be connected at the center and be supplied from either substation. The transmission line is partly aerial and partly underground. The aerial line consists of No. 0 hard drawn copper wire strung on the railroad company's transmission line poles on the inside pins of the lower cross arm. The underground line consists of

Fig. 496. Polyphase Track Relay.

Fig. 497. Alternating Current Tractive Split-phase Line Relay.

No. 6 twin conductor lead covered cable run in tile ducts or iron pipe as required.

Small 2,200 to 55-volt line transformers, from 1 to 5 k.w. capacity, are suitably located near each group of signals or other required centers of distribution, as shown at L T, Fig. 487. They are connected to the aerial lines by plug cutouts so designed that a transformer may be disconnected without danger. They are connected to the cable lines by combined fuse and junction boxes (Figs. 492 and 514). Cartridge fuses are supported on porcelain insulators and mounted in separate slate compartments, and the cables terminate on binding posts so that either cable may be disconnected without disturbing the other. Fig. 492 shows one of these junction boxes, together with a line transformer and its housing as it appears in certain locations. The 55-volt line transformer secondaries are protected from the 2,200-volt primary in case of insulation failure by a grounded shield (shown in Fig. 487).

Double rail A. C. track circuits with iron core reactance bonds (Fig. 485) are employed. Each reactance bond is wound with eight turns of copper, having a sectional area of one square inch, with a continuous carrying capacity per track of 5,000 amperes, a short-time overload of 10,000 amperes and an unbalancing capacity of over 1,000 amperes, the latter without varying the reactance over 5 per cent. The apparent resistance of the bond to alternating current is approximately five-one hundredths of an ohm.

The bonds are provided with an adjustable air gap in the magnetic circuit to limit the effect of unbalancing, as explained above, so that the reactance or unbalancing capacity can be varied as required to suit local conditions. The bonds are put up in pairs (Figs. 494-495), and mounted in iron cases (Figs. 493-494). They are set between or outside of tracks, as shown by Fig. 493. A connecting chamber is provided in the case between the coils, in which all coil ends terminate and where all connections to the rails, transformers,

Fig. 498. Track Boxes Containing Track Transformers and Track Relays; also Grid Box. New York Central.

Fig. 499. Relay Box.

NOTE.—In Fig. 498, the box to the left and resistance grid mounted above it are for use on a "single rail" track circuit, and the one shown closed, on the right, is for a "double rail" circuit. The resistance grid for the double rail circuit is smaller than the one shown and is placed in the same box with the relay.

Fig. 500. Four-track Signal Bridge. Electric Zone, New York Central & Hudson River.

relays and cross bonds, are made and then concealed by a suitable cover.

The copper connections after leaving the bond terminals go downward and underground to the rails, where, after passing for a short distance above ground to insure flexibility, they are connected to the rails. This construction leaves the space between the ties and rails free from obstruction (thus facilitating the repair of the tracks), and also conceals the copper as much as possible, tending to prevent theft. The bond connections to rails consist of two 500,000 circular mil flexible cables in multiple. The coils are immersed in transformer oil.

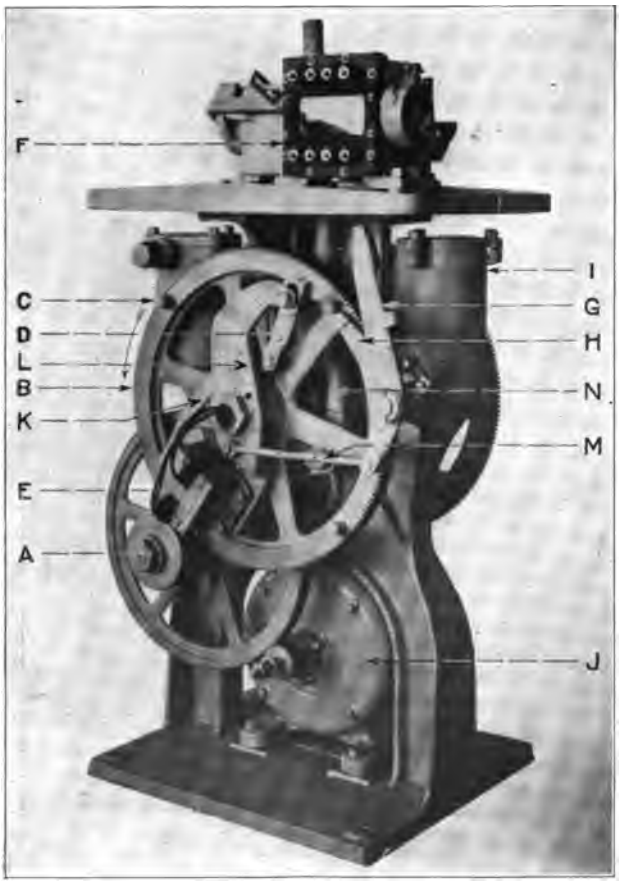


Fig. 501. Alternating Current Semaphore Signal Mechanism.

The track circuits and relay local phases are supplied with energy from small track transformers shown in Figs. 489-490, and at TT, Fig. 487. The transformers are wound for a primary voltage of 55, a track secondary voltage, variable by means of taps, from 2 to 6, and a relay secondary giving two volts, Fig. 491. The transformers have a closed magnetic circuit and are provided with slate terminal boards having a binding post for each terminal or tap. They are oil cooled, and are kept in waterproof iron cases, provided with six outgoing flexible leads as shown in Fig. 498.

The track relays at present employed on the Electric Zone are of the single contact polyphase type, as shown by Fig. 496, and P, Fig. 487. (The relay in Fig. 496 has four contacts, however). They are used as primary relays to operate secondary or repeater track relays, which in turn are equipped with a suitable number of contacts for the control of the various circuits. These secondary relays are shown in Fig. 497 and at S, Fig. 487, and will be described later. The various moving contacts of the track relays (Fig. 496) are mounted on a horizontal wooden bar to which motion is imparted by means of the small two-phase induction motor as already described. One phase is connected to the rails and the other to the track transformer, as shown at P, Fig. 487. Of the energy in the two relay windings, that supplied by the transformer direct is by far the greater. This requires but a small amount of energy from the track to give positive action on the contacts and as a result comparatively long track circuits can be operated with a minimum of energy. The relay is immune to the effects of direct current and can be made immune to the effects of A. C. traction currents by employing a distinctively different frequency for signaling as formerly described, it being apparent that the relay cannot operate unless the frequency in the track and local phases is in synchronism. All contacts and other working parts are visible through glass covered openings. Rubber gaskets make the relay water-tight. These relays give a rubbing pressure between the contacts in closing and are wide opening when de-energized. Contacts can be provided up to a maximum of four front and four back, per relay. They are insulated to stand a breakdown pressure of 3,300 volts alternating potential.

The secondary track relays as mentioned above and all motor control relays are of the A. C. tractive type shown in Fig. 497. The secondary track relays are also shown at S, and the home and distant motor control relays at H and D, respectively, Fig. 487. These relays are equipped with a three-legged laminated magnet having coils of different reactance whereby a phase difference between the two coils is produced, the combination resulting in a uniform magnetic pull when the relay is energized by single-phase alternating current. The relay has a capacity of four front and four back contacts and is wound to operate on 55 volts. It is glass enclosed and made water-tight by gaskets. The track secondary

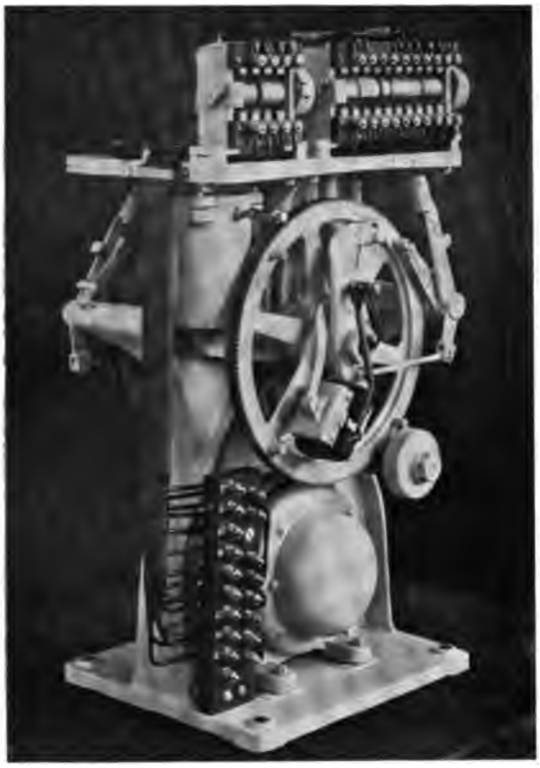


Fig. 502. A. C. Semaphore Signal Mechanism; Signal in Stop Position.

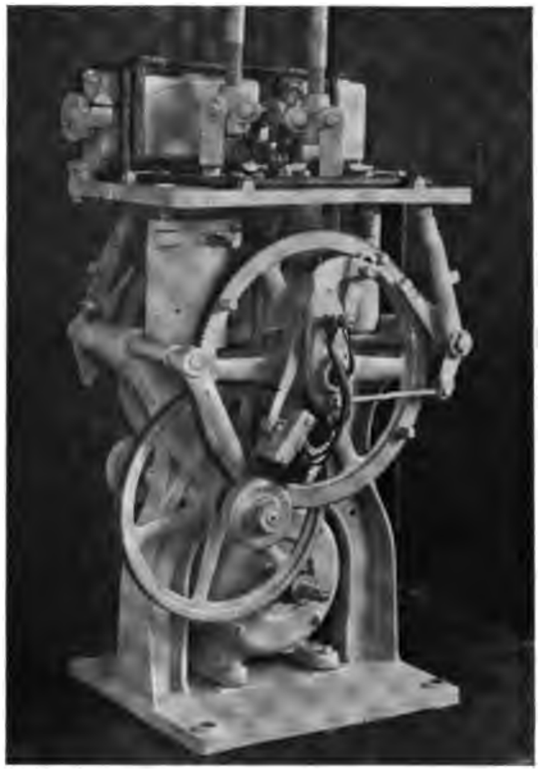


Fig. 503. A. C. Semaphore Signal Mechanism; Motor Starter and Slot Engaged.

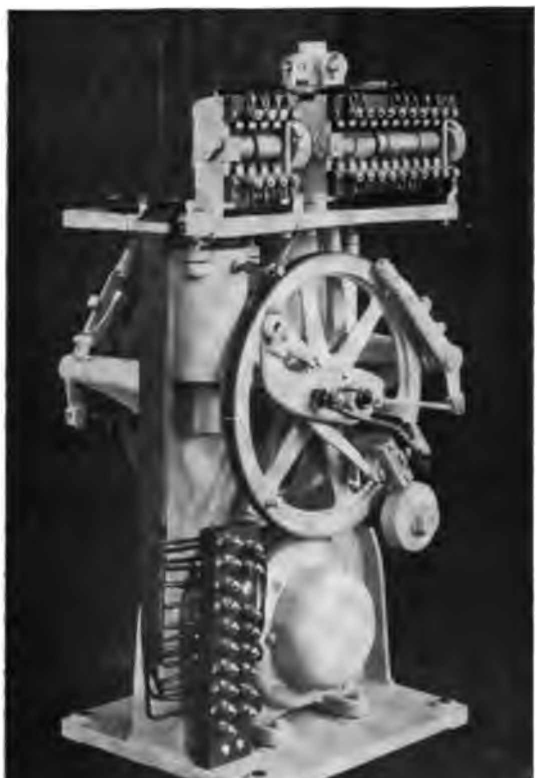


Fig. 504. A. C. Semaphore Signal Mechanism; Signal in Clear Position.

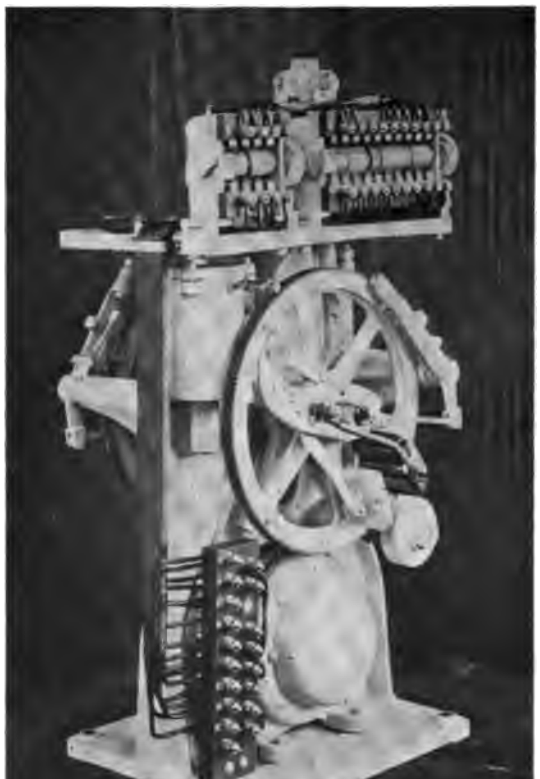


Fig. 505. A. C. Semaphore Signal Mechanism; Slot Disengaged; Signal About to Go to Stop Position.

Fig. 506. Tunnel Signal; Lights Only; Front View.

Fig. 507. Tunnel Signal; Lights Only; Rear View, with Doors Open.

Fig. 508. Tunnel Signal; Lights Only; Rear View, with Doors Closed.

relays are equipped with platinum to graphite contacts and the motor control relays with heavy carbon to carbon contacts.

The signal mechanism, Figs. 501-505, is designed for heavy duty, high speed service, it being necessary to clear the signals in two seconds. On account of the heavy spectacle used, the upward thrust on the operating rod is over 200 lbs. The mechanism is operated by a ¼ h. p. single-phase induction motor having starting and working coils, as shown at S C and W C, respectively, Fig. 487. An automatic centrifugal switch, C, Fig. 487, is used to open the starting coil as the motor speeds up. The motor revolves in one direction in clearing the home arm and in the other direction in clearing the distant arm, a ratchet arrangement, A, Fig. 501, being provided for this purpose. Motion is imparted to the signal operating rods by slot wheels B. Projecting from the sides of the slot wheels are pins C which, as the wheel revolves, engage the slot dogs D in such a manner as to clear the signal when the slot magnet E is energized. When the signal arm has reached the clear position (Fig. 504), circuit breaker F snaps over and the motor stops. The movement of the signal is limited by the stop arm G, this arm becoming effective only when the slot E is energized, and is so arranged that a stop is moved into the path of one of the pins C at the right time which limits the forward movement of wheel B, bringing the signal arm to the proper position regardless of the speed of clearing. The pawl H falls in behind the pin in question and prevents the slot wheel from moving backward. The slot is of the three-leg type as shown at E and is designed to give a uniform pull, without noise or vibration, when energized by alternating current at 25 cycles. It has a high drop-away point. The circuit breaker contacts are enclosed in a dust proof case with a glass front, mounted at the top of the mechanism as shown at F. The dashpots I are of the buffer type allowing a free initial movement of the arm in returning to the stop position. A slate terminal board (Figs. 502-505), is provided with binding posts for all incoming wires, these posts being connected to the various electrical parts of the mechanism by formed cables.

Fig. 500 shows a typical four-track bridge equipped with signals. Relay boxes are located at each end of the bridge deck, the line transformer being located on the deck at the right. The "track boxes" which hold the track relay, track transformer and resistances are shown located on the ground near each corner of the bridge legs.

Fig. 499 shows a typical relay box, with the fuse, lightning arrester and terminal board mounted at the top and with the relays on the shelves beneath, an additional terminal board being provided with each. Fig. 498 shows a typical iron "track box" in which is mounted the track transformer and track relay with a slate terminal board to which all incoming wires are brought and terminate on binding posts as shown. The track relay is enclosed in the second wooden box. Above the track box is shown the "grid box" in which is mounted the cast iron resistance grids used for limiting the flow of current as already explained. This grid is also shown at G, Fig. 487.

Fig. 487 shows a complete typical block signal circuit, four signals being illustrated to show all the circuit combinations from clear to stop. In connection with signals 1 and 7, the connections of the signal mechanisms are shown; signal 1 being clear and signal 7 in the stop position. To avoid confusion, the mechanism wiring for signals 3 and 5 is not shown, the control wires running direct to the arms, it being understood that when current is applied to a control wire, the arm in question will clear. The various devices represented in Fig. 487 have been described, and the operation of these circuits will be self-evident without further explanation.

Letters Refer to List of Names of Parts Below.

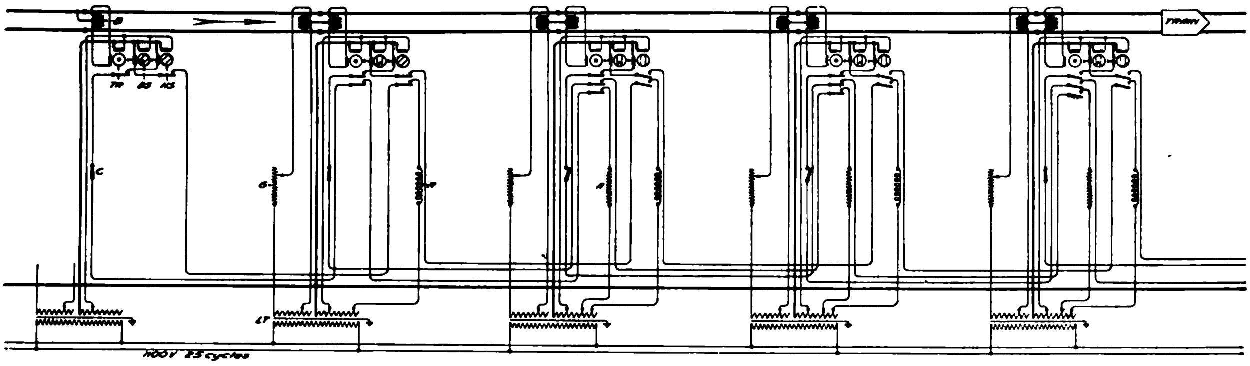


Fig. 509. Diagram of Block Signal Circuits. Hudson & Manhattan Railroad.

Names of Parts of Fig. 509.

A *Resistance Coil*	**D S** *Distant Signal*	**L T** *Line and Track Transformer*
B *Iron Core Reactance Bond*	**G** *Resistance Grid, Adjustable*	**R** *Reactance Coil*
C *Contact Closed by Automatic Train Stop*	**H S** *Home Signal*	**T R** *Polyphase Track Relay*

AUTOMATIC BLOCK SIGNALS. HUDSON & MANHATTAN RAILROAD.

On the Hudson & Manhattan Railroad signals are controlled by two rail A. C. track circuits with iron core reactance bonds. There is a double overlap so that a train is always protected by three home and four distant signals. The signals are of the illuminated disk type, having no arms and giving indications by colored lights only. A front view of the mechanism is shown in Fig. 516 and a rear view in Fig. 517. It consists of a two-phase induction motor mounted in a suitable case. The shaft is connected through a gear and pinion to a vane which passes in front of two electric lights connected in parallel. This motor is constructed like the relay shown in Figs. 496 and 522. The lights burn continuously and behind each one is a mirror placed at an angle of 45° to the front of the case, so that should one light be extinguished the illumination from the other will be reflected out of the opening by the two mirrors. The signal consists of an iron case shown in Figs. 518-519. The lenses set into the case are colored, the one on the right is red and the one on the left green. The mechanisms are set on shelves in the case, the home above and the distant below. The home mechanism is equipped with contact arms like a relay. These arms are used to control circuits (Fig. 509). The reactance bonds are made in separate sections (Figs. 510 and 511) and connected by heavy copper bonds. Relays are mounted in iron boxes the bases of which contain the train stop control apparatus (Fig. 515). Only one transformer (Fig. 512) is used at each signal location. Suitable secondary connections are provided (Fig. 509) for the different circuits. Junction boxes are shown in Figs 513-514. The resistance grid may be seen on top of the relay box (Fig. 515). The train stop apparatus is operated by a motor, the control circuits for same being omitted from Fig. 509 to avoid confusion.

Fig. 510. Reactance Bond, for Hudson & Manhattan Railroad.

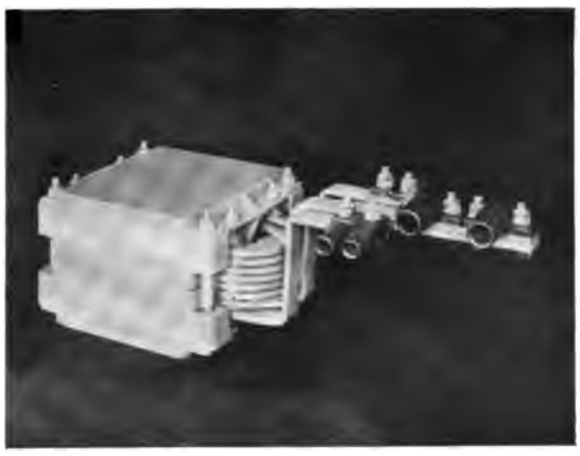


Fig. 511. Reactance Bond, Coils and Core. Hudson & Manhattan Railroad.

Fig. 512. Transformer.

Fig. 513. Low Potential Junction Box. Hudson & Manhattan Railroad.

Fig. 514. High Potential Junction Box.

Fig. 515. Relay Box; Train Stop Control Apparatus in Bottom Compartment. Hudson & Manhattan Railroad.

Fig. 516. Front View of Tunnel Signal Mechanism. Hudson & Manhattan Railroad.

Fig. 517. Rear View of Tunnel Signal Mechanism. Hudson & Manhattan Railroad.

Fig. 518. Front View of Tunnel Signal. Hudson & Manhattan Railroad.

Fig. 519. Rear View of Tunnel Signal, with Door of Case Open. Hudson & Manhattan Railroad.

AUTOMATIC BLOCK SIGNALS ON THE PHILADELPHIA & WESTERN RAILROAD

This road is a double track, high speed, direct current electric line, and is equipped with automatic block signals, the essential features of which are as follows:

First: The retention of both rails of each track for the return of the propulsion current.

Second: Cross-bonding facilities between all rails of both tracks at the ends of all track circuits and between one rail of each track intermediate between the ends of said sections, wherever desired.

Third: The use of ironless reactance bonds, permitting very long track circuits to be operated with a small expenditure of energy.

Fourth: The use of alternating currents only for the track circuits and the operation of all the devices connected with the system, thus doing away with all batteries and the expense incident to their maintenance.

Single arm, two-position home signals arranged on the normally clear principle are employed with an overlap. Between Philadelphia and Beechwood Park the signals average about 3,300 ft. apart and a full block overlap is employed, permitting a two-minute headway.

Fig. 520. Automatic Signal, Reactance Bonds, Transformer, Relay Box and Grid Box. Philadelphia & Western Railroad.

Fig. 520a. Ironless Reactance Bonds. Philadelphia & Western Railroad.

Fig. 521. Polyphase Track Relay, with Heavy Current Contacts, for Control of Track Circuit.

Fig. 522. Back View of Polyphase Track Relay.

Fig. 523. Signal Mechanism in Case. Philadelphia & Western Railroad.

Names of Parts of Fig. 524.

A *Single Coil Reactance Bond*
B *Double Coil Reactance Bond*
C *Signal Lights*
D *Polyphase Track Relay*
E *Track Circuit Control Relay*
F *Motor Control Relay*
G *Resistance Grid*
H *Line Transformer*
K *Diagonal Bond*

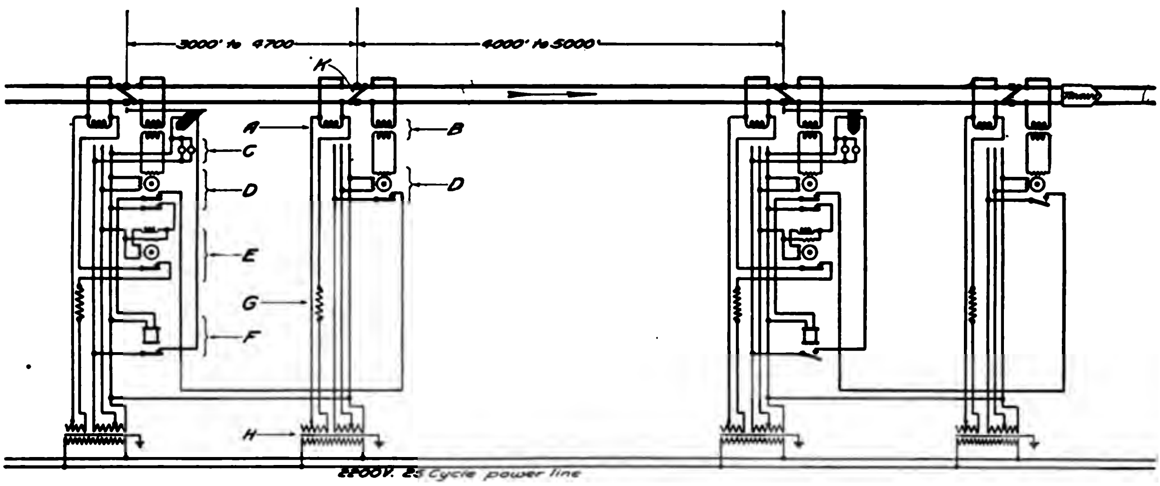


Fig. 524. Automatic Block Signal Circuits. Philadelphia & Western Railroad.

West of the Park the signal spacing averages one and one-half miles with a uniform overlap of about 3,700 feet, allowing a headway of approximately five minutes.

Twenty-five cycle single phase alternating current is used for the operation of the entire signal system. It is obtained from the secondaries of the railroad company's power transformers located in their main power house. The transmission line consists of two No. 6 B. & S., hard drawn bare copper wires strung on separate cross arms on the railroad company's high tension pole line. The line is protected at intervals by suitable lightning arresters.

Line transformers are installed at all signal and overlap locations. They step down directly from the transmission line voltage of 2,300 to the various voltages required for the signal system. These transformers are protected on the primary side by suitable cartridge fuses mounted in water-tight cast-iron boxes and so arranged that a fuse can be replaced without danger. The secondary windings are three in number, a 55-volt winding for the operation of the signal motors, lights and line relays, and provided with a tap for the local phases of all polyphase relays and two windings for supplying energy to the track circuits, taps being provided on these windings so that the voltage can be varied from 2½ to 15, as required for track circuits of different length. A copper shield is placed between the primary and secondary windings and connected to ground, affording protection in case of a breakdown in insulation.

Both rails of each track are made available for the propulsion current by the use of ironless reactance bonds (Fig. 520a) connected to the rails as shown at A and B on the circuit plan, Fig. 524, and operating as explained in connection with Fig. 484. It is to be noted that alternate rails in adjacent track circuits are connected by heavy diagonal bonds, K, so arranged that the breaking down of any insulated rail joint will short circuit either the relay or transformer and prevent the giving of a false clear indication. Cross-bonding between tracks may be effected by making connection, at any point desired, to the rails which are made continuous by the diagonal bonds K. The bonds in question are made up of flat copper strips of large cross section wound in the form of a spiral, the turns being suitably insulated from each other. These coils are assembled in pairs in flat iron cases and mounted on extended ties as shown in Fig. 520. A connecting chamber is provided in the case between the coils in which all the coil ends terminate and where all connections to the rails, relays and transformers are made and then concealed by a suitable cover. The copper connections to the rails after leaving the bonds go directly downward and under ground to the rails where, after passing for a short distance above ground to insure flexibility, are connected to the rails. Energy is supplied to the track circuits

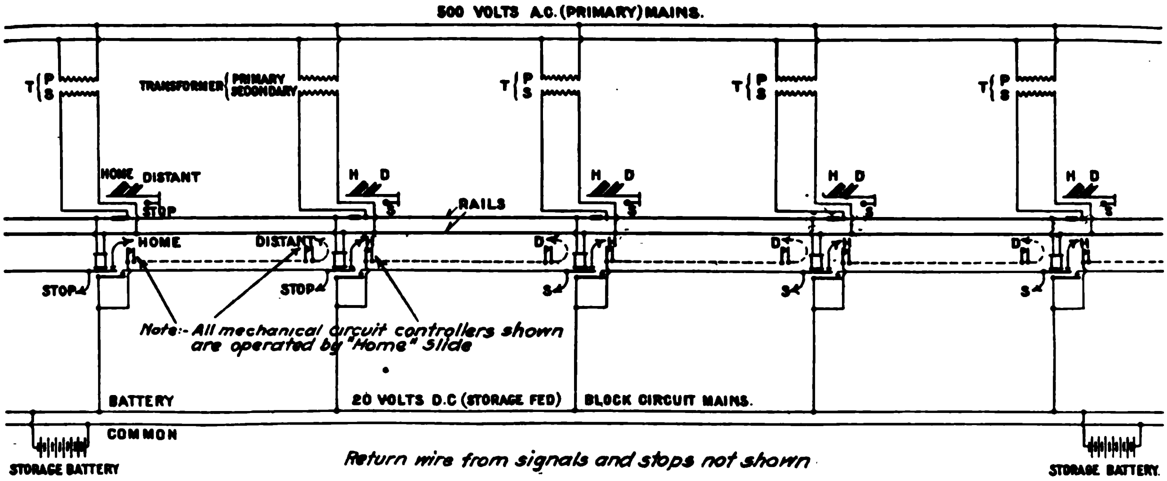


Fig. 525. Diagram of Signal Control Circuits. Interborough Rapid Transit Company.

directly from the low voltage high current windings on the line transformer, as shown on the circuit plan, Fig. 524, through adjustable cast iron resistance girds which limit the current flow when a train is standing at the transformer.

The track relays, as shown at D, Fig. 524, are of the General Railway Signal Company's polyphase construction. The track circuit control relays, as shown by Fig. 522 and at E, Fig. 524, are for the purpose of holding a given signal at stop until the train is out of the overlap beyond the next signal in advance. The method by which this control of the signals is effected will be evident by reference to the circuit plan, Fig. 524. It will be noted that these relays must be able to carry continuously and break the entire current flowing to the track circuit at the rear of a signal, and, of course, must continue to do so without injury. The construction and operation of these relays is similar to that of the track relays except that the contacts are made very much heavier and the necessary phase displacement to produce rotation is effected by a small reactance coil, placed in series with one of the relay windings. The motor control relay is shown in Fig. 497 and also at F, Fig. 524. It is controlled by the two-track circuits in advance of a given signal in such manner that it cannot close until the train is out of the overlap, as shown by the circuit plan. This relay directly controls the clearing of the signal. The signal mechanism employed is shown in Fig. 523. All signals are lighted by two 4-c.p. 50-volt lamps in multiple.

All relays are housed in wooden boxes which in turn are enclosed in cast-iron boxes, as shown in Fig. 598. In the lower part of the iron boxes are mounted the terminal boards where all outgoing wires terminate on suitable binding posts and to which all apparatus within the boxes themselves are connected by flexible leads. All transformer secondary fuses are also mounted on this board. The relay boxes, grid boxes and line transformers are mounted one above the other on suitable poles provided for the purpose as shown in Fig. 520.

Fig. 526. Track Transformer Coils and Core. The Union Switch & Signal Company.

Fig. 527. Impedance Coil Used on Single Rail Alternating Current Track Circuit.

AUTOMATIC BLOCK SIGNALS ON THE INTERBOROUGH RAPID TRANSIT COMPANY'S SUBWAY DIVISION.

The arrangement of block signals installed on the Subway Division of the Interborough Rapid Transit Company consists of the automatic overlapping system shown in Fig. 536, applied to the two middle express tracks and to the third track on the west side branch. This third track is placed between the two local tracks, and is used for express traffic in both directions. The apparatus used differs little in general principle from that employed in earlier automatic systems of block signaling, the substitution of alternating current in place of battery current for the track circuit, and the necessary alternating current auxiliary apparatus, constituting the principal change. In detail of application to the peculiar requirements under subway conditions, however, the system embodies many radical features.

In Fig. 525 is shown a diagram of the block signal and automatic train stop circuits as used in connection with the overlapping feature of this system.

In this system of signaling one of the running rails of each track is insulated from the propulsion-current return system and is devoted to signal purposes. Thus, the other rail performs the function of serving simultaneously as conductor for the direct-current return for the propulsion system, as well as that of one of the conductors for the alternating-current track circuit for controlling the signals. The current is fed into each block at the end from which the passing train leaves it, the connections to the signal-control apparatus being made from the opposite, or entering, end of the block, as shown in the circuit diagram. The track connections at the signal end of the block lead from the track circuit to the alternating-current signal-control relay, which operates secondary connections in the various circuits of the signaling system. This relay operates double contacts, so that when the block is clear and current is thus passing through it, two separate circuits are closed; one of these is the circuit leading to the automatic train stop at the entrance to the block in the rear.

The distant, or caution signals are operated by an auxiliary circuit as the result of the setting of the home signal. When the home signal of a block is clear, current passes through the control mechanism of the distant signal of the preceding block thus holding it clear also. When the home signal is changed to the stop position the current flowing in the auxiliary circuit is interrupted by a circuit controller on the home signal, which causes the distant signal to indicate caution.

The alternating-current for the track circuits is supplied by high-voltage alternating-current mains which run the entire length of the tunnel. These deliver current to the signal blocks at 500 volts potential, from which it is stepped down at each block by a double-secondary oil transformer, one coil of which feeds the track circuit and the other the signal-lamp circuit. The magnet-control apparatus, which is used for operating the controlling air valves for the signal cylinders, receive current from a storage-battery main which also runs the length of the subway. This main is fed by several sets of 16-volt storage batteries in duplicate, which batteries are located at the various interlocking towers and are charged by motor generators.

In Fig. 535 is shown the arrangement of the apparatus installed at a block-signal location. It consists of the block signal, the transformer, a case for the track-circuit instruments and the automatic stop valve box. The transformer takes current from the 500-volt main through 3-amp. enclosed fuses to the primary coil; its secondary contains two coils, one of which delivers current at 50 volts for use in the 4 c.p. incandescent lamps used in the signal, while the other coil delivers current at the lower voltage (10 volts) for use in the track circuit. The leads to the track circuits pass down the instrument case and thence to the rail connections at the exit end of the block; in the instrument case they pass through non-inductive grid-resistances of 1 ohm, which serve to prevent any large amount of current from flowing through these circuits in case of abnormal disturbing conditions in the propulsion return current, and also prevent an excessive alternating current passing from the transformer when short-circuited by the presence of a train in the track circuit which it feeds.

The alternating-current track relay is shown in Figs. 530-534. The principle of operation involved is that of the action of an alternating-current field upon a slotted metallic (non-magnetic) vane, which is caused to move in such a way as to close the two circuit contacts. The alternating-current field is supplied by a magnet of

Figs. 528-529. Non-inductive Resistance Grids Used in A. C. Track Circuits.

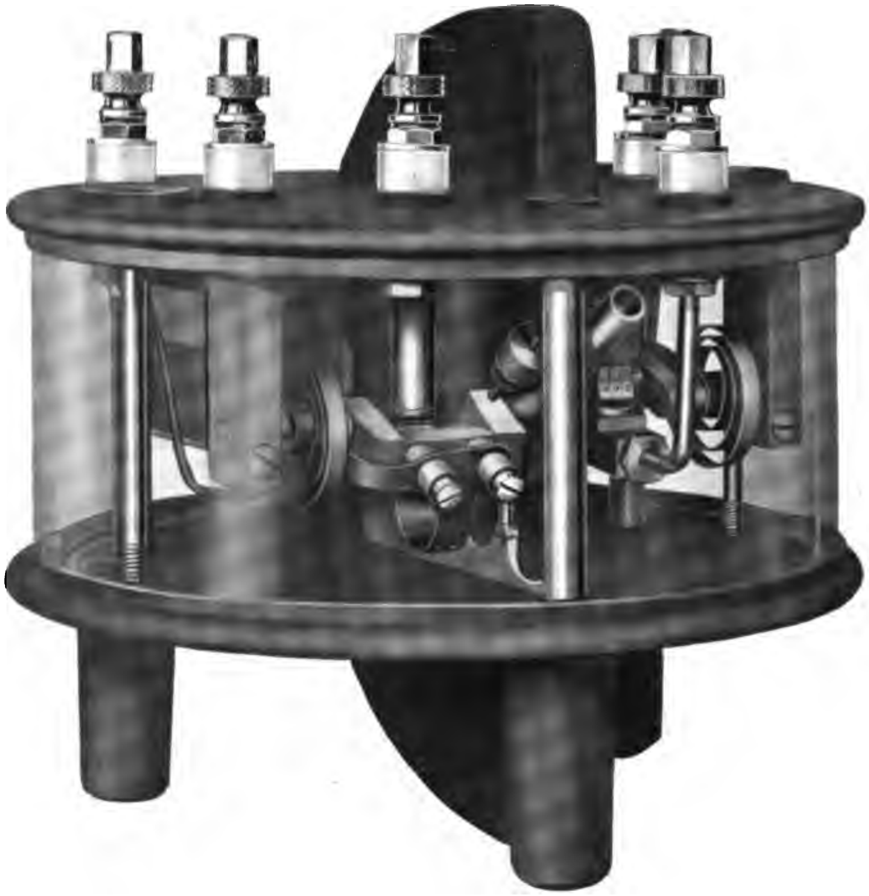
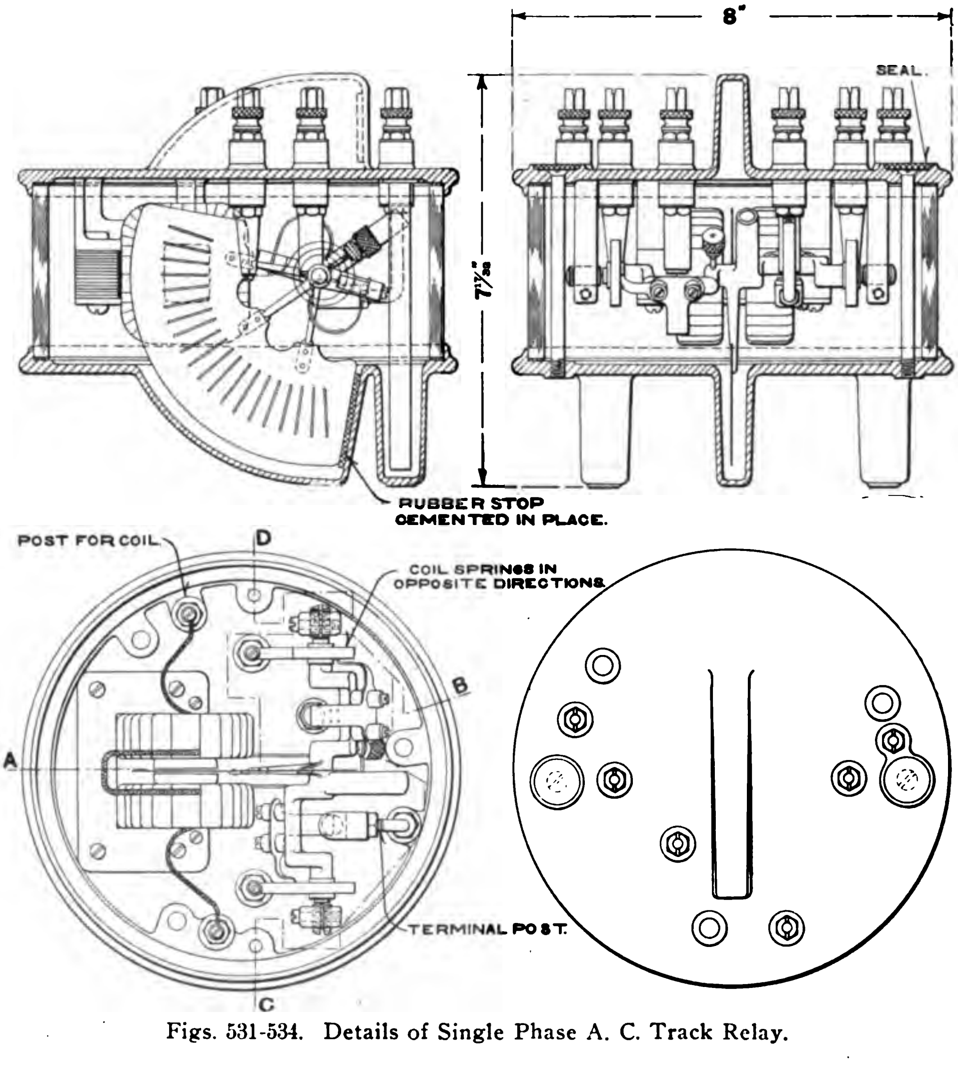


Fig. 530. Single Phase Alternating Current Track Relay.



Figs. 531-534. Details of Single Phase A. C. Track Relay.

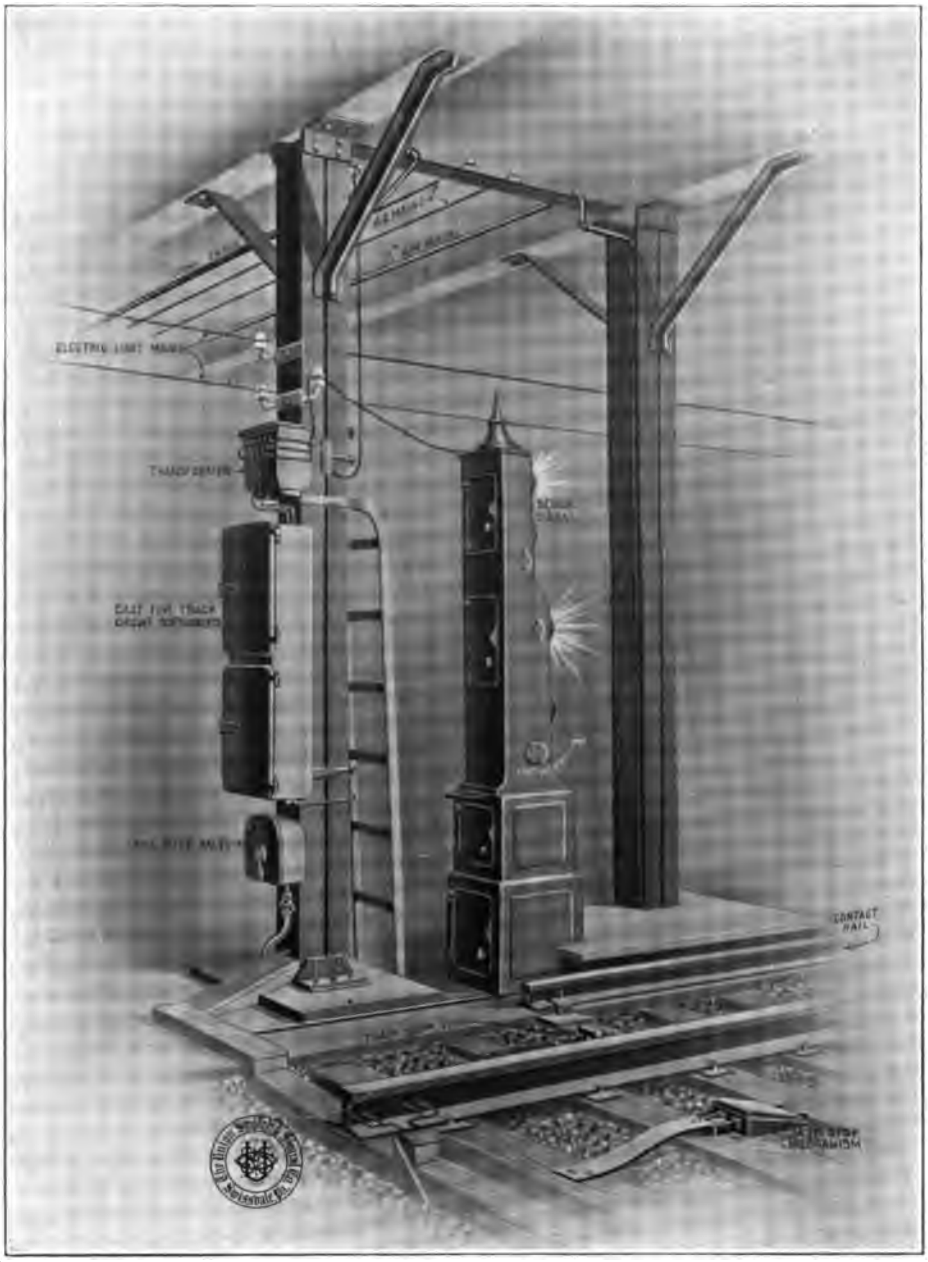


Fig. 535. Automatic Signal, Transformer, Instrument Case and Automatic Train Stop. Interborough Rapid Transit Company.

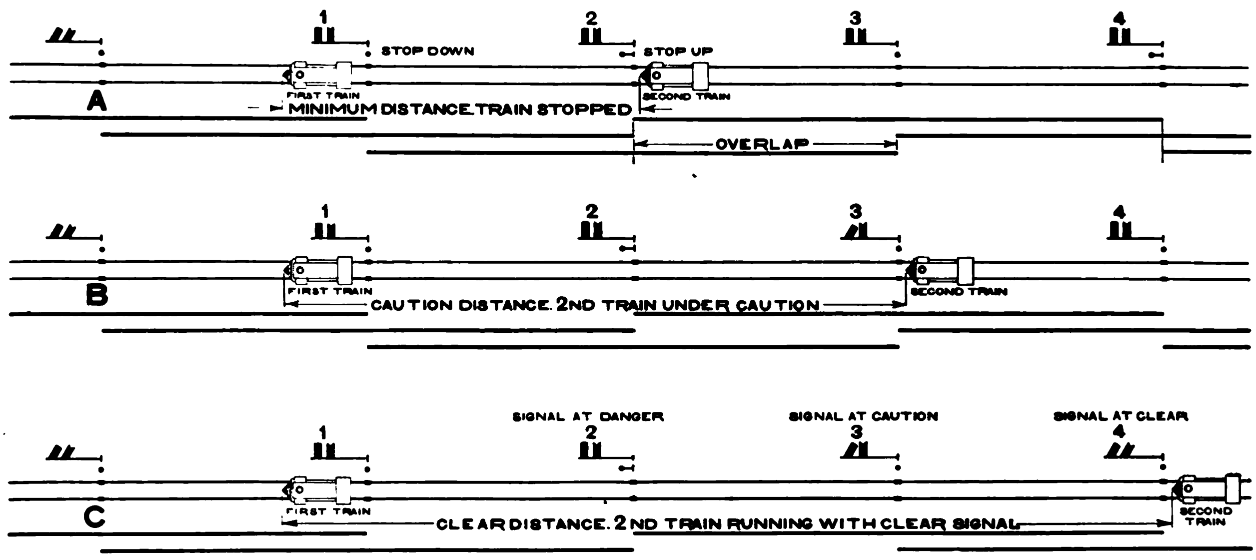
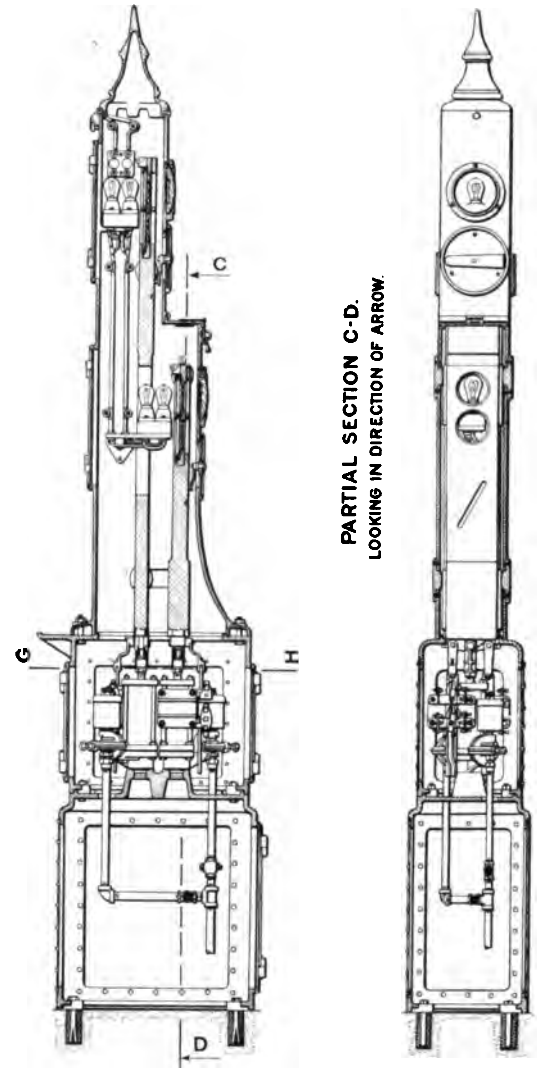
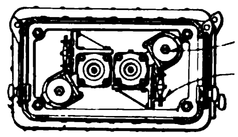


Fig. 536. Diagram of Overlapping Block Signal System. Interborough Rapid Transit Company.



SECTION G-H.



Figs. 537-538. Sectional View of Electro-Pneumatic Slide Signal Mechanism and Case. Interborough Rapid Transit Company.

Fig. 539. Alternating Current Relay, Wire Wound Armature. West Jersey & Seashore Railroad.

laminated field-core construction, with the field coils arranged very close to the pole faces. The vane, which is of aluminum, is pivoted in a vertical position on jewel bearings. The upper half of each pole piece is enclosed by a copper ferrule set into a notch. The ferrule is so arranged that half the lines of force in the field must pass through it. Any change in the number of lines of force through the ferrule will set up an electromotive force in the ferrule acting to produce a current. The direction of this current will be opposite to that producing the charge in the field and will itself tend to produce lines of force in opposition to the field. In other words, change from zero lines of force to maximum and back to zero will be retarded in the "shaded" or ferrule-enclosed half of the field. This will cause the magnetic flux to shift from the lower to the upper portion of the field at each reversal of polarity. Now currents are generated about the slots in the vane by the field flux the same as in the ferrule. These currents will produce fields of their own opposite to the main field, and will act against the main field and be repelled by it in the same manner as like magnetic poles. But the sifting flux in the main field due to the ferrules is constantly moving upward. Therefore the vane is raised. The action is similar to that between fields and squirrel-cage armature in a polyphase induction motor.

The track relay and associated apparatus are housed in a cast-iron instrument case of water-tight construction, as shown in Fig. 535. This consists of two sections, the lower part containing the relay and connections, and the upper part the grid resistances, Figs. 528, 529, which are connected, one in series with the transformer supplying alternating current to the track circuit, and the other in series with the track relay.

The impedance coil, Fig. 527, is connected in multiple with the track relay and shunts out any propulsion current that might have a tendency to pass through it.

A seven-conductor cable leads to the signal nearby, while another seven-conductor cable leads to a junction box from which connections are made to the distant signal mechanism in the preceding block and to the automatic stop, as well as to the storage-battery mains for the direct-current supply for the signal mechanism. Four conductors lead out to make the necessary connections with the rails on each side of the insulated joints.

The signal (Figs. 537-538 and 540-541) consists of a vertical iron case fitted with two white lenses, the upper being the home signal and the lower the distant. Suitable colored glasses are mounted in slides, which are operated by pneumatic cylinders. Home signals show a red light for the stop indication. Distant signals show a yellow light for the caution indication. All signals show a green light for the "proceed" or clear indication. A positive indication has been provided for, as an auxiliary to the color indications, in the form of a small arm immediate beneath the lenses. The small arm appears in a horizontal position when a stop or caution signal is displayed, and at an inclination of 60 degs. when clear, this being provided in addition to the color indications for use in case of failure of the lamps for the color indications. The blade has a crank extending within the case and ending in a pin which plays in an inclined groove in such a way as to turn the blade through an angle of 60 degs. as the slide passes from upper to lower position. The signal consists of two sections; the upper and rear portion contains the lenses and position indicator for the home signal. The front and lower portion of the case contains the distant signal mechanism. Each lens is constantly lighted by two 4-cp. incandescent lamps at the rear, the two lamps being connected in parallel in order that one may be always lighted even if the other burns out. The pneumatic cylinders, which operate the heavy vertical sliding frames carrying the colored glass for the signal indications, are located in the base of the case. The slides exhibit the green color for the clear indication only when held in its upper position by the pneumatic cylinder; in this way any accident to the apparatus, cutting off the compressed air, will permit the slides to drop and indicate red or stop. The signals which are used on the exterior elevated portions of the system are of the semaphore type, although operated similarly

Figs. 540-541. Double Electro-pneumatic Slide Signal. Interborough Rapid Transit Company.

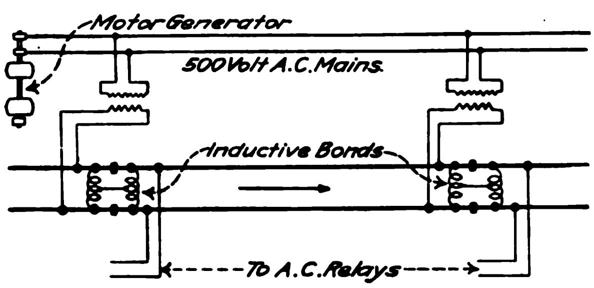


Fig. 542. Diagram of Transformer and Single Phase Track Relay Connections, as Used in the East Boston Tunnel. Both Running Rails Used for Propulsion Current Return.

to those in the subway sections and by a similar construction of mechanism.

Automatic train stops are provided and arranged so as to act at the second stop signal in rear (see Figs. 525 and 536). That is to say, the train stop does not operate as soon as the signal, at which it is situated, goes to the stop position, but stays down until the train enters the overlap section, when it comes up in place to "trip" a train, should one run past the red signal. This arrangement is necessary in order to permit every car of a train to be fitted with the automatic brake valve, and at the same time not be "tripped" by the forward portion of the train entering the block. The signals are so placed that, at maximum speed, a train would be brought to a stop by the automatic application of the brakes before it could reach a preceding train.

This arrangement of apparatus, but without the overlap and train stops, was first used on the North Shore Railroad of California.

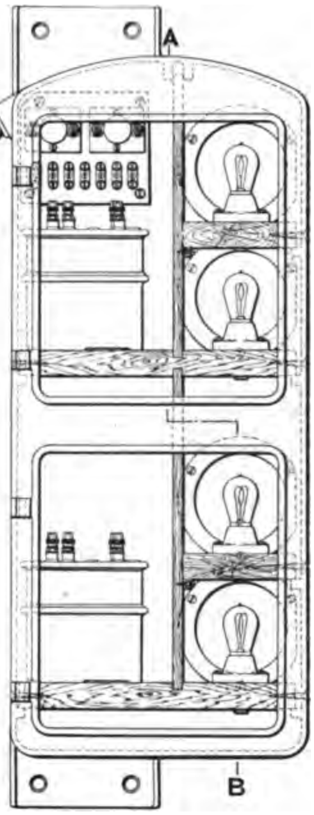


Fig. 543. Back View, Cover Removed.

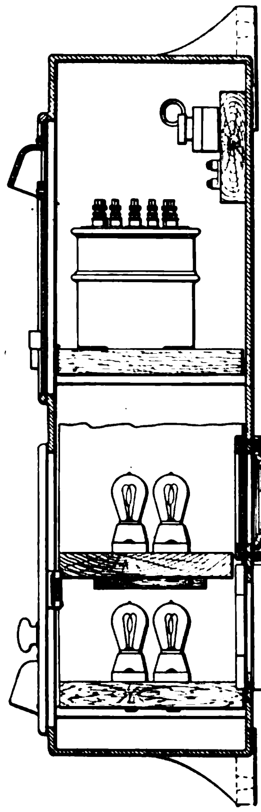


Fig. 544. Side View, Section A-B.

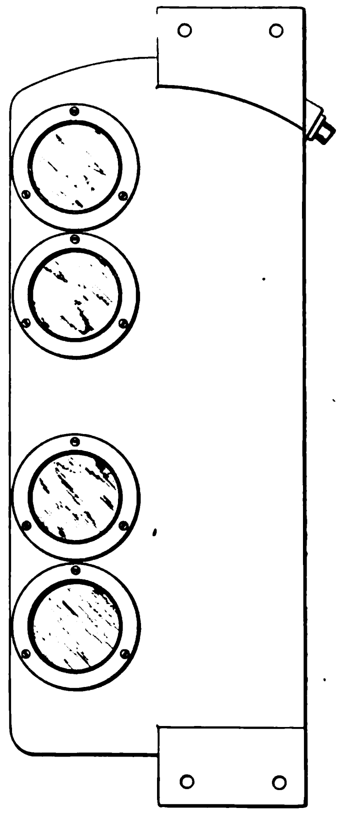


Fig. 545. Front View.

Figs. 543-545. Double Electric Light Subway Signals. Long Island Railroad.

AUTOMATIC BLOCK SIGNALS ON THE ELECTRIFIED LINES OF THE LONG ISLAND RAILROAD

In the electrification of this road a third rail is used for delivery of the propulsion current and both of the running rails for its return. Direct current is used for propulsion and alternating current for signal track circuits, with inductive rail bonds, Fig. 547, installed at the insulated joints separating different track sections, which give a free path for the propulsion current. Automatic signals are of the motor type (Fig. 427), with the exception of the two subways, where an electric light signal is used (Figs. 543-545). The lights in this signal are controlled by alternating-current line relays, which in turn are controlled by the track relays (Figs. 530-534).

On seven miles of double track, which has also been equipped with alternating-current track circuits for the signals, the inductive rail bond is not used, as this part of the road is not worked by electric traction. The alternating-current track circuit, nevertheless, was installed here for the operation of the existing system of automatic signals in this territory, on account of a third track on this division, which is electrified, and runs parallel with the two main tracks.

The length of the sections ranges from 1,000 to 1,200 ft., with the transformers (Fig. 526) connected at one end of the section, and from 1,300 ft. to 2,800 ft. with the transformers connected in intermediate positions.

The motor signals used are of the Union Switch & Signal Co.'s standard style B type (Fig. 427). Current for the motors and the line relays is taken from two sets of storage batteries installed at every pair of signals and so arranged that one set is being charged while the other set is discharging. The charging current is taken from the third rail at 650 volts through a high resistance so proportioned that just the necessary current flows into the batteries. A 100-kilowatt transformer supplies the high-tension mains with the

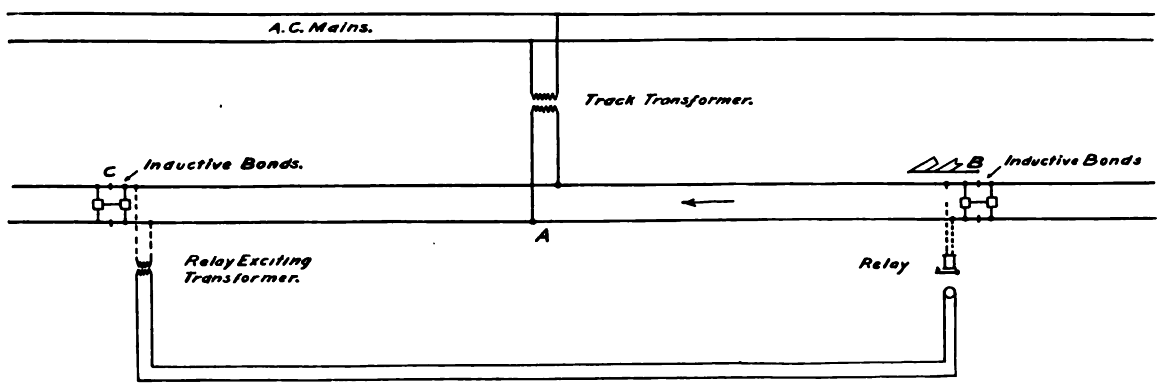


Fig. 546. Diagram of Transformer and Track Circuit Connections. West Jersey & Seashore Railroad.

Fig. 547. Inductive Bond in Place. Long Island Railroad.

current at a potential of 2,200 volts and a frequency of 25 cycles.

These mains are carried underground in a lead cable for about eight miles, and on the high-tension transmission pole line for the rest of the system. From the alternating-current main taps are brought into the primary transformers where the potential is reduced to 55 volts. This is in turn reduced in another set of transformers, called track transformers, to from two to six volts as the conditions of the different track sections require. In the subways the lights in the signals and all line relays are also supplied from the 55-volt side of the primary transformers.

In the subway and on the elevated structure, full block overlaps are used.

AUTOMATIC BLOCK SIGNALS ON THE WEST JERSEY & SEASHORE RAILROAD

The automatic electro-pneumatic signals are controlled by alternating-current track circuits flowing through the running rails, which also convey the return direct current of the propulsion system; and the air compressors are run by electric motors supplied with current from the third rail.

Fig. 546 is a diagram of a typical track circuit. In consequence of the difficulty of conveying alternating current through the rails of the track under the existing conditions, the track circuit is conveyed from the transformer to the rails in the middle of the block section, as shown. Thus, in a signal section 4,000 ft. long the current has to pass through only 2,000 ft. of track. The track relay (Fig. 539) is controlled not only by the track circuit, but also by the current through the line wires, as shown in the lower part of the drawing.

On the West Jersey & Seashore the propulsion current conditions were as follows: Maximum capacity of each sub-station in amperes, 3,500 to 7,000, ultimate; normal average output of each sub-station in amperes, 1,500; number of amperes to start trains on a level, 500 to 1,200 amperes per car; number of cars per train, six.

The inductive bonds and their connections which have been put in to meet these conditions introduce in each rail a resistance per block equivalent to only about 40 ft. of 100-lb. rail, so that in the 4,000-ft. blocks the increase in the resistance of that part of the propulsion return system formed by the rails is only 1 per cent. The relays are of the motor type, the armature and the field both having coils which are energized when the current flows. The field is supplied by the 25-cycle current taken from the rails at the entering end of the block. The armature is supplied by the current from the leaving end of the block and the current, which is taken from the rails at the leaving end, is stepped up for transmission by a 6-watt transformer. The transformers are not injuriously affected by being short circuited by trains standing opposite them. Their primaries are fed by the 1,100-volt, 25-cycle signal mains running from the sub-stations. At each sub-station there is a switchboard for handling the signaling current, which is stepped down to the signal line voltage from one leg of the propulsion mains. The switchboard is supplied with indicating instruments for showing the voltage of the signal mains and of the current going in either direction. Recording watt-meters are provided to determine how much power is used by the track circuits. The arrangement of oil switches is such that the signal mains can be disconnected on either side of the sub-station, or made continuous and disconnected from the sub-station.

Oil line switches are fixed in the signal mains midway between the sub-stations, so that in case of line trouble a maintainer can, without risk to himself, open the line and limit the trouble to the territory in which it exists.

ALTERNATING CURRENT AUTOMATIC BLOCK SIGNALS ON THE NEW YORK, NEW HAVEN & HARTFORD

Figs. 548-549 show the type of automatic signals installed by the Union Switch & Signal Company on a section of the New York, New Haven & Hartford Railroad. This section is used both for steam and electric traction, the electric cars taking direct current from an overhead trolley wire. Through the entire length of the signaled section there is a 10,000-volt, three-phase, 60-cycle commercial line giving a reliable 24-hour service. From this supply current is procured for the signal system, the connection being made through step-down transformers. The transformers are connected to one phase of the high potential line, stepping the current down from 10,000-volt to 2,200-volt and connecting through oil switches to the signal transmission lines which extend the entire length of the signal system. From this 2,200-volt, 60-cycle line, current is obtained through transformers for the various signal requirements. The automatic signals have home and distant arms, pivoted near the center and mounted upon the same post. The eastbound and the westbound signals are placed nearly opposite each other, but are staggered sufficiently to avoid putting a signal where a trolley pole will hide it from the

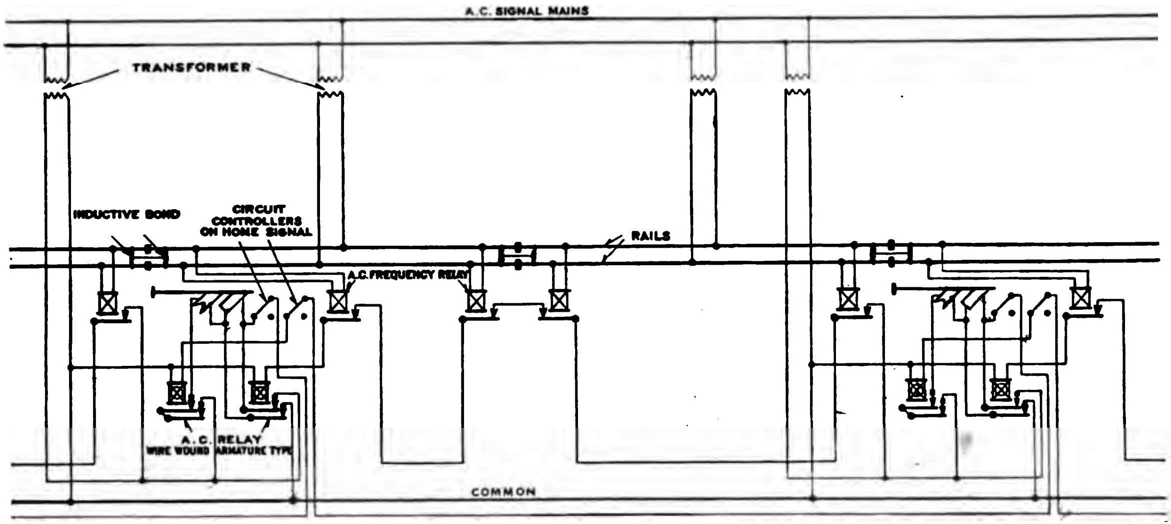


Fig. 548. Arrangement of Control Circuits for Normal Clear Alternating Current Automatic Block Signals. New York, New Haven & Hartford.

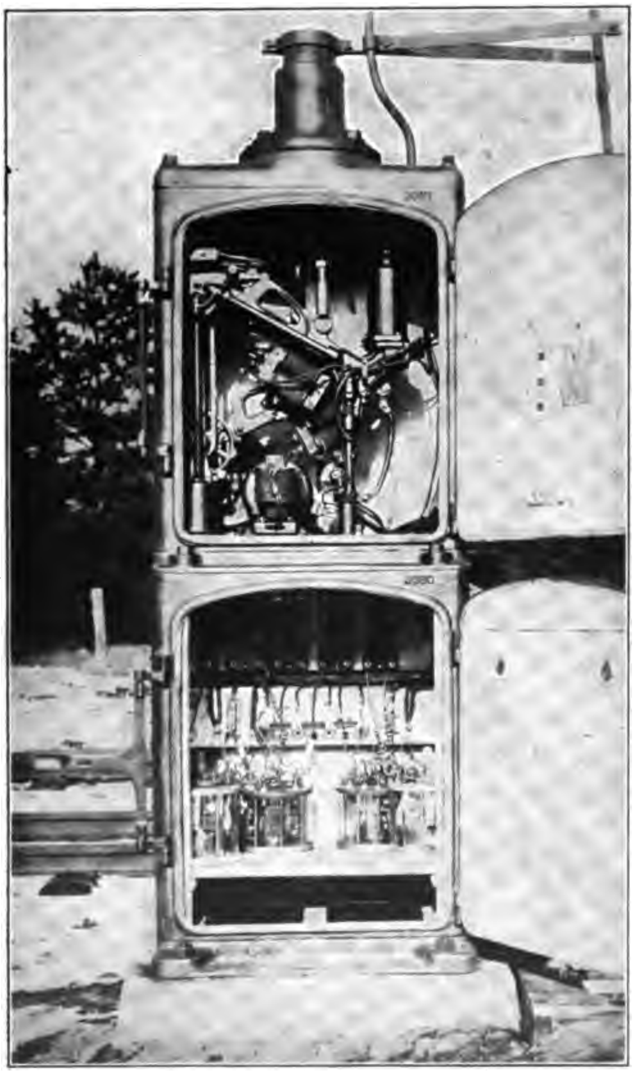


Fig. 549. Alternating Current Signal Mechanism and Relays in Case. New York, New Haven & Hartford.

engineman. The blade grip castings are designed to permit the arm to extend to the left of the post for the reason that the trolley poles would obstruct the view of the signal if it extended only to the right.

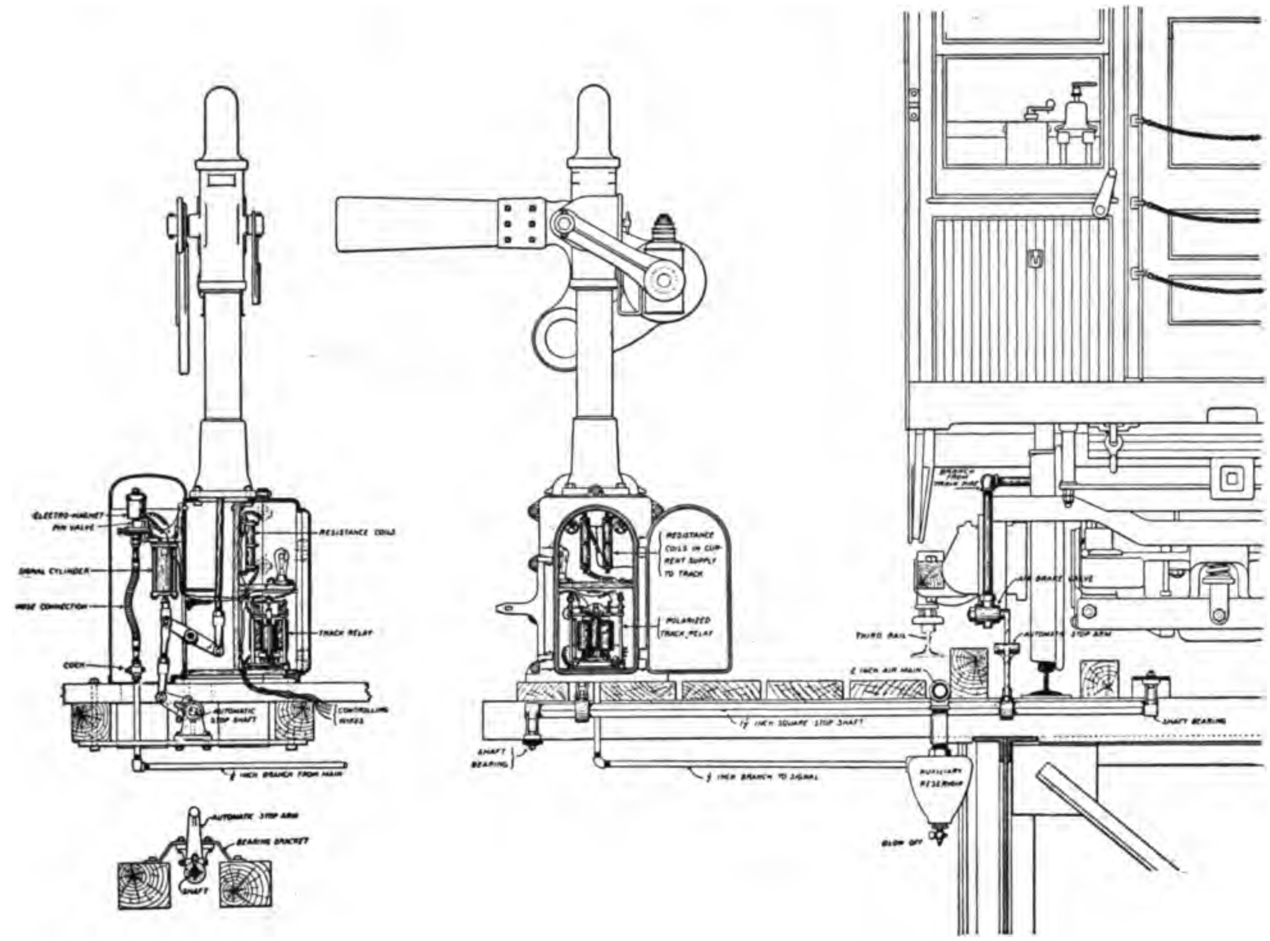
The motor signals have double-case bases and rest on concrete foundations. The upper case contains the signal mechanism which is operated by a 110-volt single-phase induction motor. The motor has sufficient torque at starting to start under load from any point in the arc through which the signal travels. The time required to clear both the home and the distant arms is five seconds. The lower case contains track relays, line relays, controlling switches, fuses and lightning arresters. Duplicate two-candle power incandescent electric lights are used in the lanterns. Oil founts are also provided.

At each signal there is a transformer stepping down from the 2,200 volt line to 110 volts to supply current for the local signals and the control circuits for the next signals in the rear. The signal control line extends the entire length of the block section, taking energy at the outgoing end and looping through the track relays and switch instruments.

The track circuit equipment installed is designed to be used with a propulsion current either direct or alternating; either 550-volt direct or 11,000-volt 25-cycle single-phase alternating. The electric railway company required that the tracks be cross bonded at least every 3,000 ft., thus making necessary a cut section in each block. Energy is supplied to the tracks by a transformer situated in the middle of a track circuit section. The track circuit has a relay at each end. These are "frequency" relays, that is to say, relays which respond only to alternating currents of a given frequency. These control the signal circuits. At each end of the track circuit there is also an inductance bond, the terminals of which are connected to the rails, and the center of which is connected to the center of the bond of the next track circuit, thus forming a metallic connection around the insulated rail joints for the return propulsion current. This center connection may also be used for cross bond connection to the other track.

The inductance bonds were designed to carry the heavy current necessary with direct-current propulsion and also were balanced to offer the least possible impedance to an alternating propulsion current. In fact, if the external track return is perfectly balanced the only impedance of the bonds may be said to be ohmic. The frequency relays are of the vane type and are immune to a direct current or to alternating current of 25 cycles, having been designed to operate at 60 cycles. The unbalancing of the track, therefore, even if sufficient to throw a heavy current through the frequency relays, would not result in a false clear signal indication. This system will, of course, not be affected by any foreign trolley current. To connect up an inductance bond to a track with "broken" or "staggered" joints, it is necessary either to cut one rail of the track so as to have the insulated joint near the bond, or to provide a conductor from the bond to connect with the track beyond the insulated joint. In this case use is made of a piece of old rail about 15 ft. long. The piece of steel rail is better than copper because it costs less and is not liable to be stolen; and besides this, if alternating current is used for propulsion, the iron serves to restore the balance of the inductance of the two lines of rails, which with one side 15 ft. shorter than the other, would be unbalanced.

Fig. 548 shows a diagram of typical circuits used in this installation.



Figs. 550-551. Arrangement of Automatic Signal and Train-Stop Apparatus on Structure. Boston Elevated Railroad.

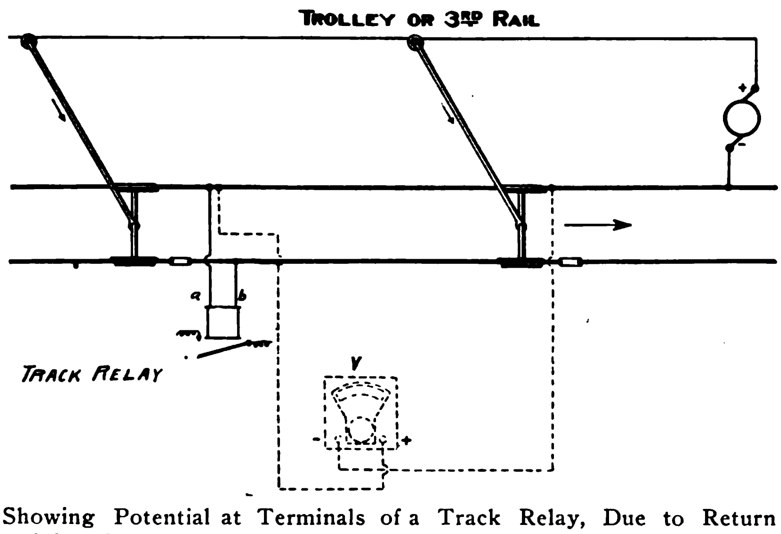


Fig. 552. Diagram Showing Potential at Terminals of a Track Relay, Due to Return Propulsion Current.
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AUTOMATIC BLOCK SIGNALS ON THE BOSTON ELEVATED RAILROAD

Figs. 550-558 illustrate the automatic block signal circuits and apparatus used on the rapid transit lines of the Boston Elevated Railroad. On this road the propulsion system uses direct current delivered by a third rail and returning by one of the running rails which is grounded to the elevated structure, the negative terminals of the propulsion generators being connected to the grounded rail. The other running rail, designated as the "block rail" in Fig. 553, is given up exclusively to signaling purposes. It is divided into sections by insulated joints, each section constituting one side of a "single rail" track circuit, the grounded rail being a common conductor for both signal and propulsion current.

This being the first installation where it was attempted to use signal track circuits together with propulsion current return on the running rails, it may be well to consider the feature known as "drop in potential" along the common rail, caused by the presence of the propulsion current.

Fig. 552 illustrates how the presence of two trains might cause a difference of potential across the relay terminals. When current is flowing in any conductor there is always a difference of potential between any two points on that conductor due to its resistance. V represents a voltmeter so connected as to measure the potential due to the flow of return propulsion current over the continuous rail. With one train at the leaving end of the block and another approaching, the relay has the same potential across its terminals as that

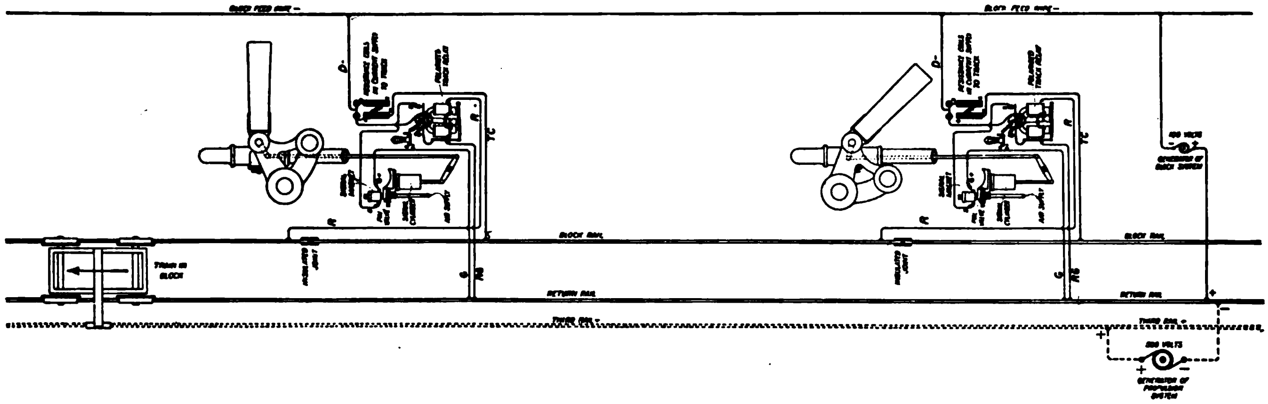


Fig. 553. Diagram of Automatic Signal Circuits and Apparatus. Boston Elevated Railroad.

measured by the voltmeter, for wire *a* connects on side at the same point as the positive lead of the meter, and wire *b*, the insulated rail, and the wheels and axles of the train at the right, connect the other side to the same point as the negative lead of the meter. Whether or not an ordinary type of relay will close its contacts under these conditions depends on whether or not the voltage at which it is adjusted to operate is greater than the drop of potential caused by the return of power current over the length of rail measured by the length of the block.

However, in the case of the Boston Elevated Railroad, the blocks are short and the common return rail is grounded at close intervals to the structure which has a copper equivalent of 14,000,000 circular mils. These conditions make it permissible to use a relay whose voltage adjustment provides against any "return drop" which may occur.

The signals are of the electro-pneumatic type made by the Union Switch & Signal Company, and operate "normally clear." Current is supplied to the signal system from 100-volt generators by the main "block feed wire" (Fig. 553) with the grounded rail of the tracks as a return. It is to be noted that the *negative* terminals of the signal generators are connected to the feed wire and the *positive* terminals to the grounded rail. An adjustable resistance is introduced between the feed wire and the block rail of each track circuit, which limits the flow of current while the block is occupied and prevents the shunting of one track circuit from affecting any of the others. The track relay is one of the notable features of this installation, being quite a departure from ordinary practice in signal work. Figs. 556-557 show this relay mounted in the mechanism case of a signal, and also the adjustable resistance tubes for the track circuit in rear. The electro-pneumatic valve and cylinder which operates the signal are placed on the back side of the partition, as shown in Fig. 550.

The relay (Fig. 554) is operated by direct current, requiring a potential of five volts at its terminals to "pick up," and is polarized; its magnet is wound to 50 ohms resistance. The horizontal armature at the base is raised by the large 50-ohm magnet, when energized, irrespective of the direction of the current. The link extending upward connects this horizontal armature to a phosphor-bronze contact plate carrying two heavy carbon blocks, one at each end, which lie under contact points of the same substance mounted above them and properly insulated. The contact plate is rigidly secured to the upper pole-piece of a pair of smaller magnets mounted transversely to the one first mentioned and pivoted on tunnions formed upon the ends of the upper pole-piece. The lower ends of these swinging magnets are joined by the lower pole-piece which hangs between the extended cores of the larger magnet, and is attracted by one or the other according to its polarity. The swinging magnets are wound to produce like poles at the same ends, hence the two pole-pieces joining them actually constitute the poles of one double magnet. The coils of the 50-ohm magnet are wound in the usual manner and included in the track circuit, being energized (when the block is unoccupied) by current from the signal generator. The right-hand contact is operated by motion of the swinging magnets.

Suppose the relay to be de-energized by the presence of a train in the block, the sequence of operation in closing the relay contacts is as follows: As soon as the train passes out of the block current flows from the positive terminal of the signal generator along the grounded rail through the 50-ohm coil of the relay at the signal on the right (Fig. 553) along the block rail, through the resistance tube at the signal on the left and back over the main feed wire to the negative terminal of the generator. This picks up the armature at the base of the relay, closes the left-hand contact, and tends mechanically to move the lower pole of the swinging magnet to the left. But as soon as the left-hand contact is closed, current passes from the grounded rail through the resistance lamp and the swinging coils to the feed wire. This circuit, energizing these magnets, causes their lower pole-piece to swing to the right, bending the contact plate and closing the right-hand contact; this latter contact completes the circuit through the signal control magnet and clears the signal. It will be seen that there is a mechanical counter effect of the swinging magnet upon the work performed by the neutral armature which will cause the latter to drop in response to a very slight reduction in current.

When a train again enters the block it shunts the 50-ohm coils causing the lower armature to drop and open both contacts. If now, while the train is in the block, the wheels should make poor contact on the grounded rail (on account of the presence of sand or ice, or for any other reason) propulsion current might flow from the wheels to the block rail and through the relay to the grounded

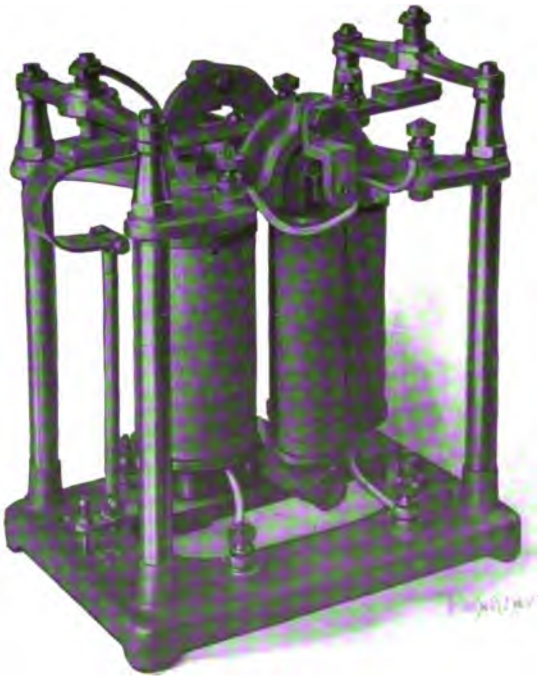


Fig. 554. Polarized Track Relay. Boston Elevated Railroad.

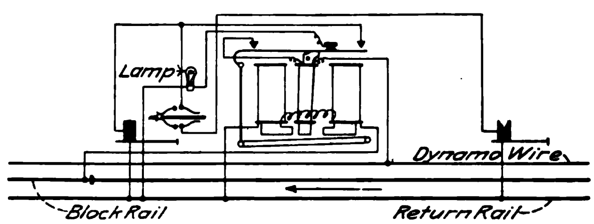


Fig. 555. Circuits for Control of Distant Signal. Boston Elevated Railroad.

Fig. 556. Relay, Resistance Tubes and Lamp in Signal Case. Boston Elevated Railroad.

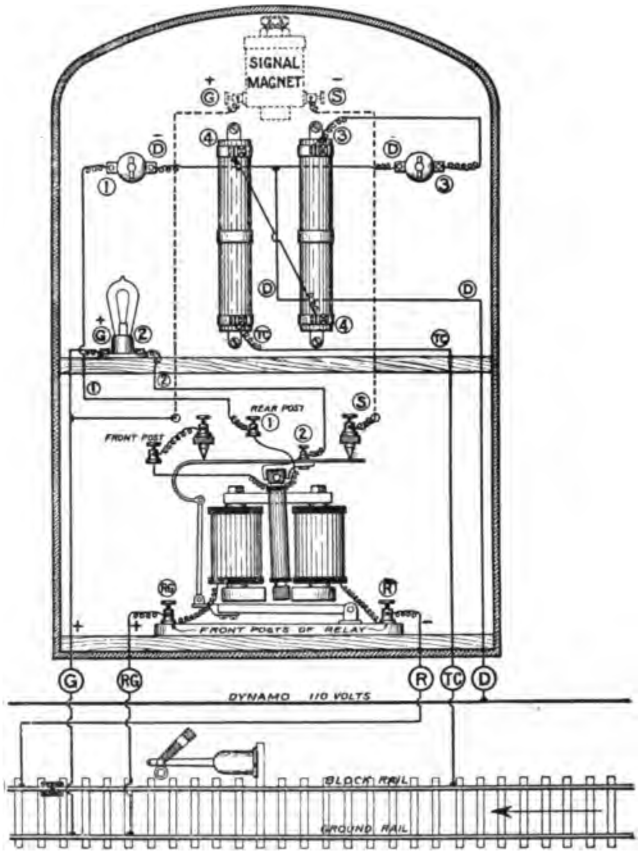


Fig. 557. Diagram of Signal Control Apparatus. Boston Elevated Railroad.

Fig. 558. Tunnel Signal and Automatic Train Stop. Boston Elevated Railroad.

rail. This would pick up the neutral armature. but in this case the polarity of the current and consequently that of the magnet is now reversed, and as soon as the left-hand contact closes permitting current to pass through the swinging coils, they are held over to the left preventing the right-hand contact from closing, and keeping the signal in the stop position. The swinging coil being in series with the signal magnet, any interruption in the circuit which might tend to depolarize the relay would also result in the signal going to the stop position.

Fig. 555 shows the circuit used for control of a distant signal.

Figs. 550-551 shows how the signal is set in relation to the track on the elevated structure, and also illustrates one method of connecting the automatic train stop, which is a feature of this installation. Fig. 558 gives a view of the tunnel signal and train-stop used in the subway. This signal has no blade, the light being its only indication. The train-stop is operated by a separate cylinder instead of by a rocker-shaft as on the structure.

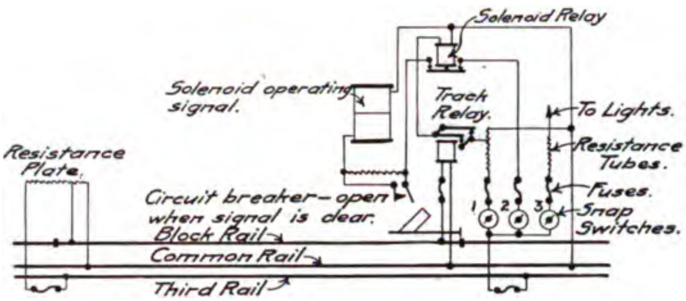


Fig. 559. Circuit Diagram for Solenoid Signal. Interborough Rapid Transit Company, Elevated Lines.

The Interborough Rapid Transit Company has in service on the elevated lines semaphore block signals, operated by solenoids energized by current taken from the third rail. The current for the track circuit is also obtained from the third rail. The apparatus and circuits for a typical block section are shown diagrammatically in Fig. 559. Only one of the track rails is insulated for the block section, which varies in length for the different locations where the signals are used. At the outgoing end of the block the third rail is connected through a fuse to a resistance plate having two taps at the upper end, one of which is connected to the insulated track rail and the other to the opposite or common track rail, which is grounded for the return power circuit. The resistance is adjusted to give a difference of potential between the two-track rails of 10 volts. At the entering end of the block the two-track rails are connected together through a two-point track relay, which is wound to pick up at three volts. The normal difference of potential of 10 volts is sufficient to care for the widest variations in voltage of the third rail current passing through the resistance plate.

At the signal, a tap from the third rail connects to a bus bar on which are three snap switches, one in the solenoid relay circuit, one in the main signal solenoid circuit, and one in the signal lamp circuit. When no train is in the block the track relay is energized and its two contacts are closed. Current from the third rail passes through switch 1, resistance, track relay armature, solenoid relay coil and thence to common rail or ground. Current also flows through switch 2, armature of solenoid relay and resistance of 3,000 ohms to solenoid coil and thence to ground, holding the signal in the proceed position.

When a train enters the block the track relay opens, releasing the spring-actuated quick-break solenoid relay, whose armature controls 600 volts. This breaks the solenoid circuit and permits the signal arm to go to stop by gravity. An oil dash pot is provided to cushion the shock of the moving arm. When the train passes out of the block the track relay picks up causing the solenoid relay in turn to pick up. Current from the third rail (at 600 volts potential) then flows through the solenoid relay armature and the circuit breaker which is closed. This gives a powerful circuit in the signal solenoid to move the signal down, but as soon as the arm reaches the proceed position the circuit breaker opens, cutting in the high resistance and allowing only a small current, enough to hold the signal in the clear position, to flow through the solenoid.

Fig. 561 shows the signal mechanism enclosed in the iron case at the foot of the post. The solenoid plunger is connected to a pivoted lever to which the dash pot is fastened at its outer end. The up and down rod is fastened about midway between the solenoid plunger and the dash pot. Resistance tubes are mounted on one side of the case and the circuit breaker attached to the up and down rod can be seen just above the dash pot. In the upper part of the case are the two relays and the snap switches. Good results have been obtained from the special track relays employed, which are made with carbon points on the springs bearing on german silver pedestals. The quick-break solenoid relays, controlling 600 voilts, have also proved satisfactory. Pittsburg insulated joints of the latest pattern are used in the track and are said to be standing up well under the heavy traffic which passes over them. The signals and relays were made by The Union Switch & Signal Company.

Fig. 560. Solenoid Semaphore Signal. Interborough Rapid Transit Company.

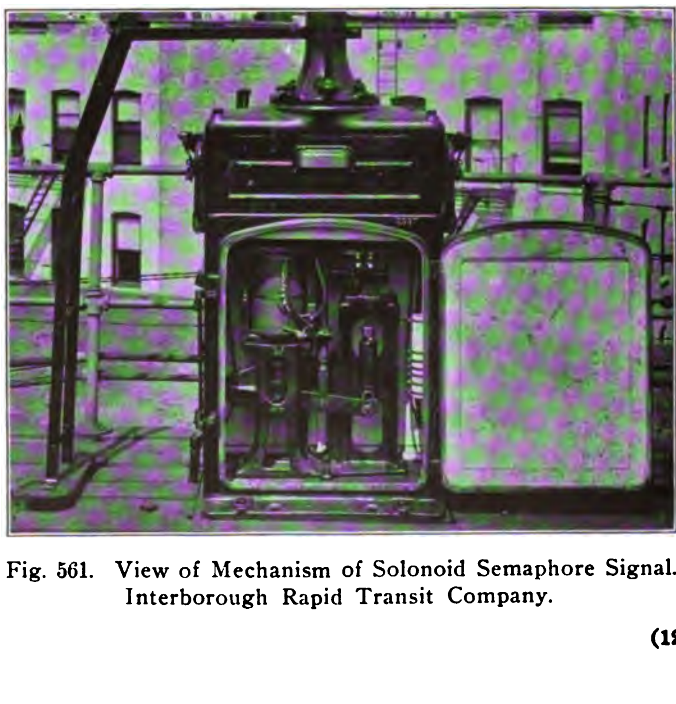
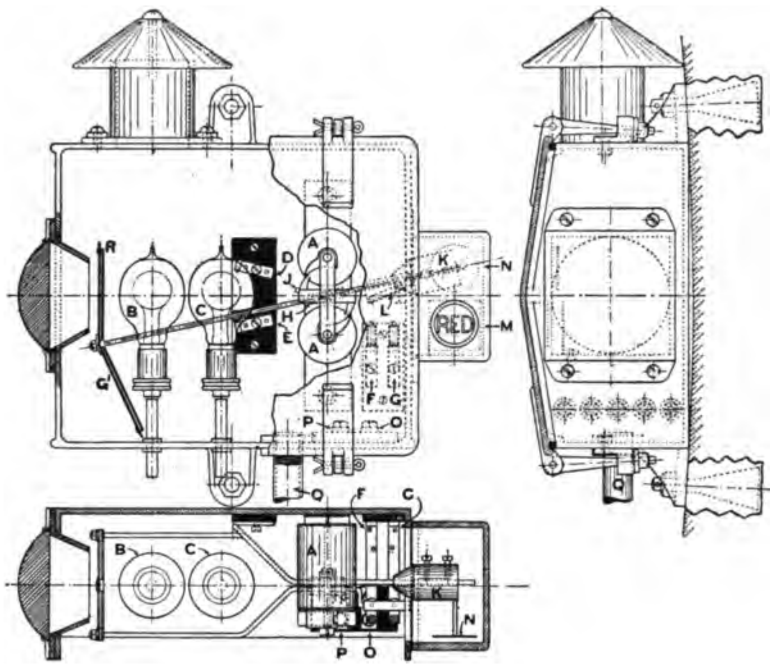


Fig. 561. View of Mechanism of Solonoid Semaphore Signal. Interborough Rapid Transit Company.

Letters Refer to List of Names of Parts Below.



Figs. 562-564. Sykes Electric Tunnel Signal. Waterloo & City Electrical Railway, London, England.

Names of Parts of Sykes Tunnel Signal; Figs. 562-564.

A	*Operating Magnet*	**G**	*Fuse*	**M**	*Opening for Indicator*
B	*Electric Light*	**G'**	*Green Glass*	**N**	*Indicator Disk*
C	*Electric Light*	**H**	*Armature*	**O**	*Binding Post*
D	*Upper Stop for Frame*	**J**	*Screw*	**P**	*Binding Post*
E	*Lower Stop for Frame*	**K**	*Counterweight*	**Q**	*Wire Conduit*
F	*Fuse*	**L**	*Contact Arm*	**R**	*Red Glass*

SYKES ELECTRIC TUNNEL SIGNAL

Figures 562-564 illustrate a simple form of signal electrically operated and electrically lighted as used in a Sykes installation on a double-track tunnel line on the Waterloo & City Electrical Railway. In the figures, A A are two coils of an electro-magnet with a Z-shaped rotating armature, to which is attached a frame extending around and in front of two white electric lights and supporting a red and a green glass between the lights and the signal lens; the red being above the green. When the magnets are de-energized by a train in the block ahead or for any other reason, the frame carrying the glasses drops by gravity, bringing the red glass in front of the lights and displaying a stop indication. When the track circuit is unoccupied and the track relay picked up, the magnets A A are energized and the armature rotates, raising the frame so as to bring the green glass in front of the lamps and display a clear signal. K is a counterweight carrying an indicator repeating the position of the signal at the side of the case.

Fig. 565. Crossing Bell, Relay Box and Battery Case, with Wooden Post. The Union Switch & Signal Company.

Fig. 566. Crossing Bell and Relay Box on Iron Post, with Crossing Sign. Bryant Zinc Company.

Fig. 567. Crossing Bell, Relay Box and Battery Case, with Iron Pipe Post and Crossing Sign. The Union Switch & Signal Company.

Fig. 568. Crossing Bell and Relay Box on Iron Post, with Sign. Bryant Zinc Company.

Fig. 569. Bell and Relay Box on Iron Post, with Sign. Bryant Zinc Company.

Fig. 570. Crossing Bell and Relay Box on Channel Iron Post, with Sign. Railroad Supply Company.

Fig. 571. Iron Crossing Sign and Instrument Case. Bryant Zinc Company.

Fig. 572. Cast Iron Bell Case and Cover. The Union Switch & Signal Company:

Fig. 573. Cast Iron Bell Case and Cover. The Union Switch & Signal Company.

Fig. 574. Bell Armature and Contacts. The Railroad Supply Company.

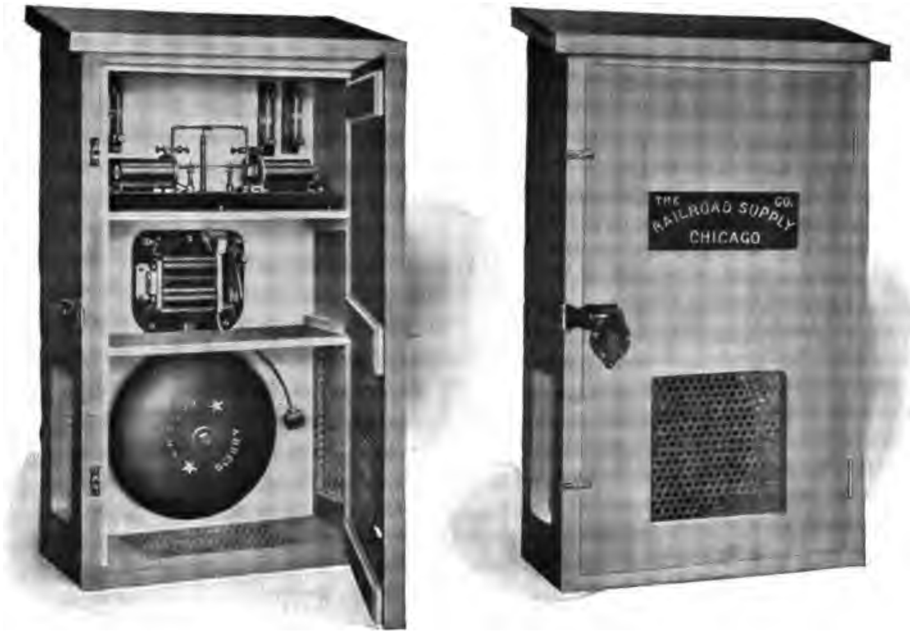
Fig. 575. Bell Mounted in Cast Iron Case. The Railroad Supply Company.

Fig. 576. Skeleton Frame Bell, with 12-in. Gong. The Railroad Supply Company.

Fig. 577. Crossing Bell, with 12-in. Steel Gong, Enclosed Mechanism, for Use on Iron Pipe Post. The Union Switch & Signal Company.

Fig. 578. Bell, with 12-in. Steel Gong. The Union Switch & Signal Company.

Fig. 579. Bell, with 10-in. Steel Gong. The Union Switch & Signal Company.



Figs. 580. Combination Bell and Relay Box. Railroad Supply Company.

Fig. 582.

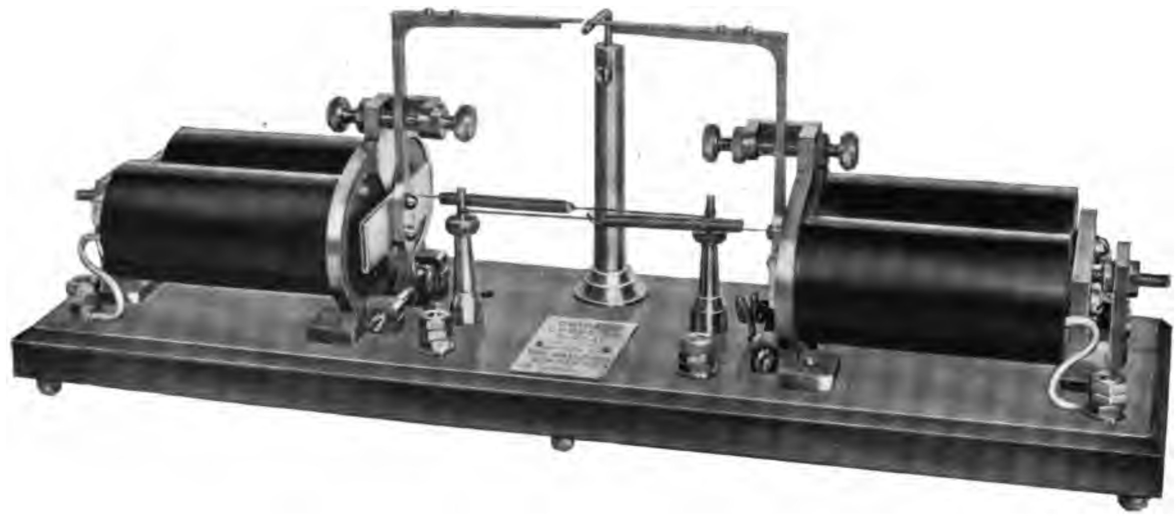
Fig. 583.

Figs. 582-583. Electric Lamp and Casing, for Use with Highway Crossing Bell.

This lamp lights on about 8 volts. It is connected in multiple with the bell, thus giving a visual indication.

Fig. 584. Double Gong Bell.

Fig. 585. Double Gong Bell.



Fgi. 586. Interlocking Relay, Normally Energized. Railroad Supply Company.

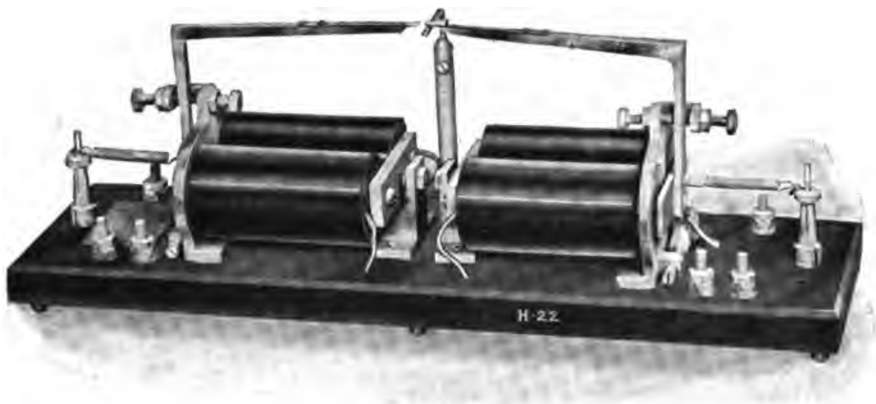


Fig. 587. Interlocking Relay, Normally De-energized.

Fig. 586 represents an interlocking relay manufactured by the Railroad Supply Company. The armatures are equipped with right-angled fingers, as shown. On the end of each finger is a flexible strip of metal which will make electrical contact with the rod on the upright when the magnet is de-energized. The metal strips are fastened to the fingers some distance back so that they can easily bend upward, but not downward. Therefore if the right-hand magnet is de-energized the strip on its armature finger will make contact with the rod; if now the left-hand magnet becomes de-energized the strip on its armature finger will rest on top of right-hand strip. The lifting of right-hand finger will now raise both strips from contact with rod. The same action would take place, but in reverse order, if the left-hand magnet had been de-energized first. Front contacts can also be furnished with this relay if desired.

The relay shown in Fig. 587 operates in a similar manner, except that it is normally de-energized and closes the contacts if either magnet is energized.

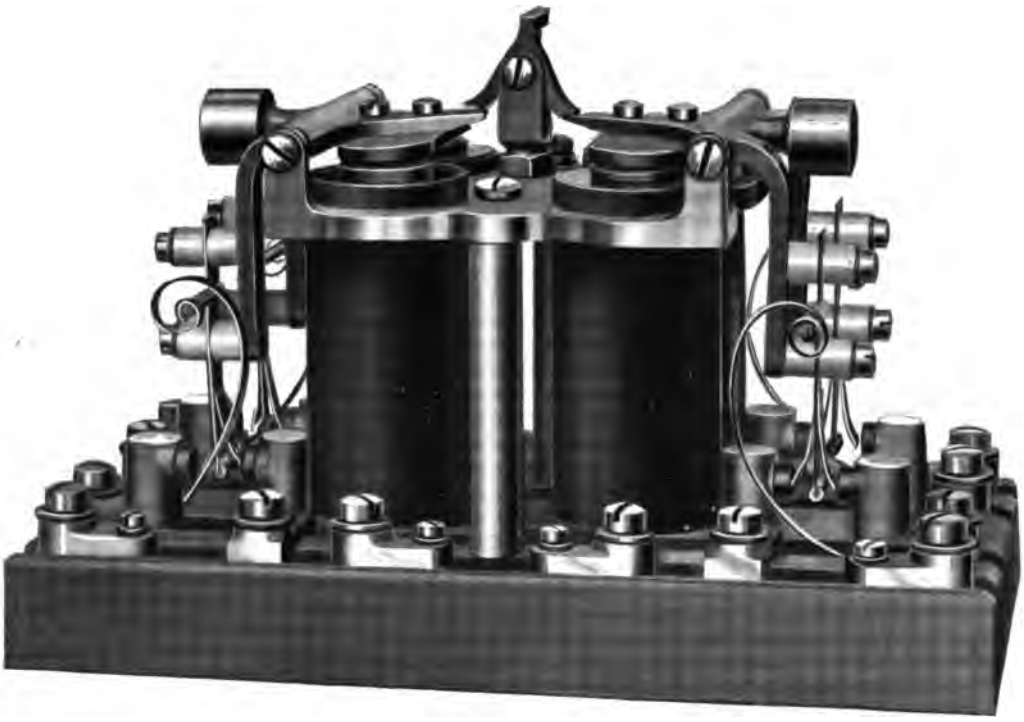


Fig. 588. Slate Base Interlocking Relay. The Union Switch & Signal Company.

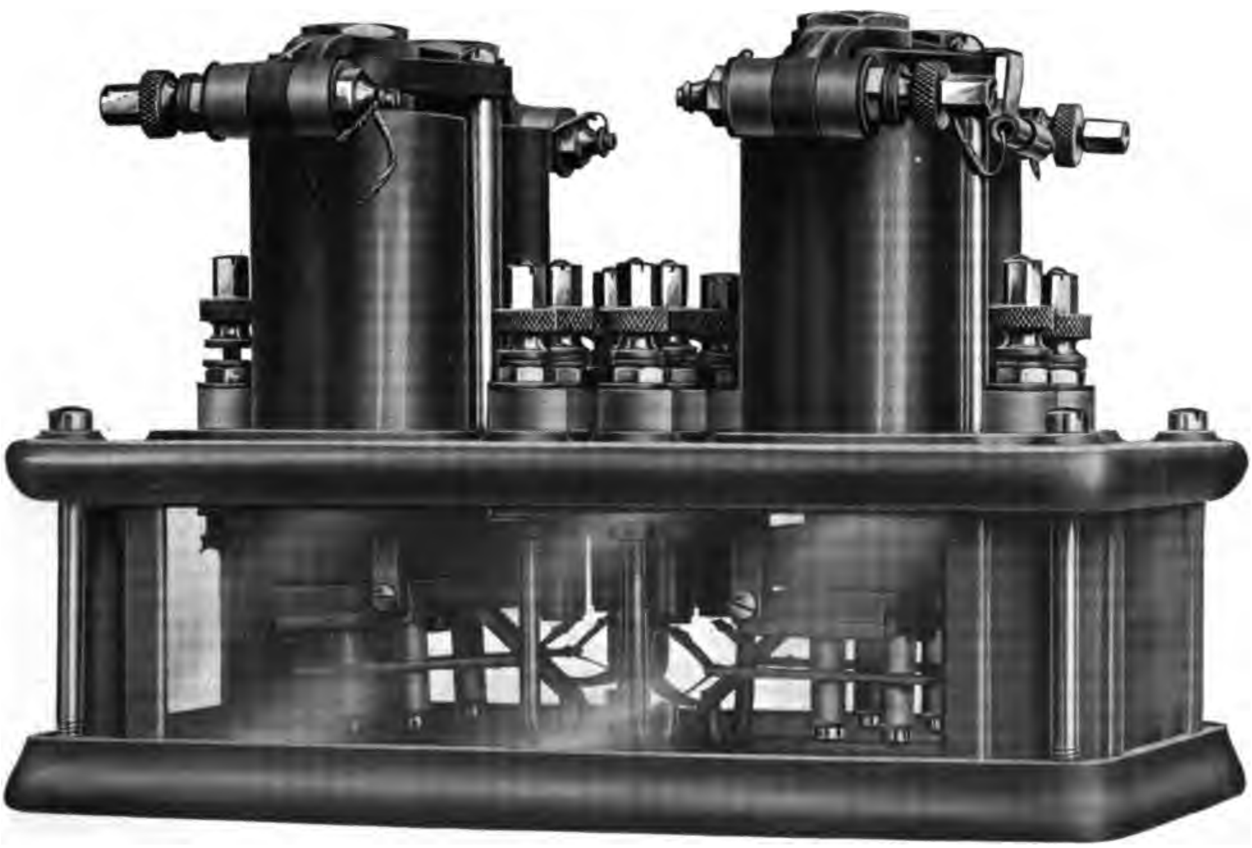


Fig. 589. Enclosed Universal Interlocking Relay.

Fig. 589 shows the enclosed "Universal" interlocking relay made by The Union Switch & Signal Company. It consists essentially of two ordinary relays mounted on one base. In this instrument, however, the contact points project beyond the hinged side of the armature, thus the back contacts are above and the front contacts below. The interlocking device consists of two arms, one projecting from each armature, which strike against a pivoted pawl. All movable parts are enclosed in a dust-proof case, forming the base of the relay.

Fig. 588 shows the slate base interlocking relay made by The Union Switch & Signal Company. The magnets are inverted so that the armature is above the pole pieces. Counterweights are provided to insure raising of the armature and opening of the contacts by gravity when the magnets are de-energized. The contact-fingers hang vertically, this form of construction being adopted to prevent foreign substances from lodging in them and interfering with the circuits. Interlocking between the armatures is accomplished in the same manner as in the enclosed relay.

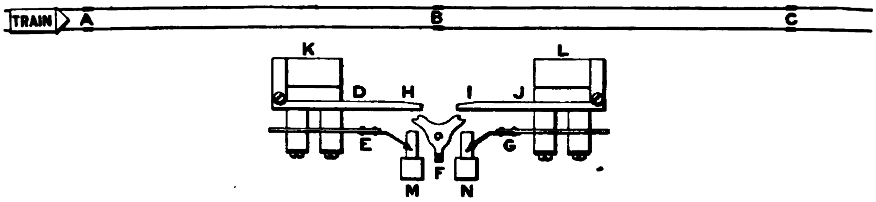


Fig. 590.

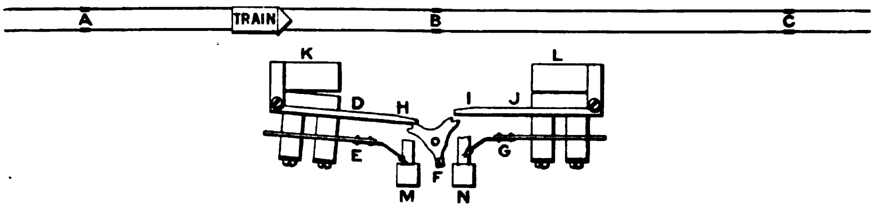


Fig. 591.

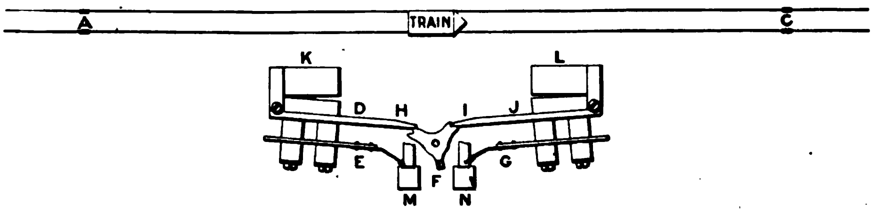


Fig. 592.

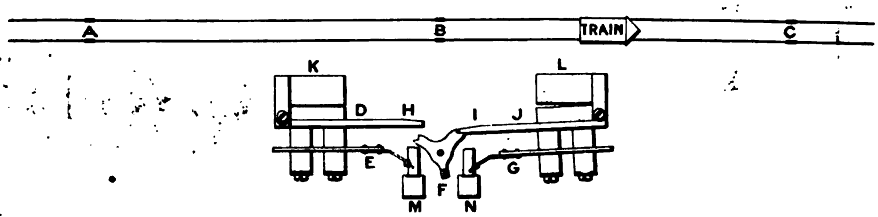


Fig. 593.

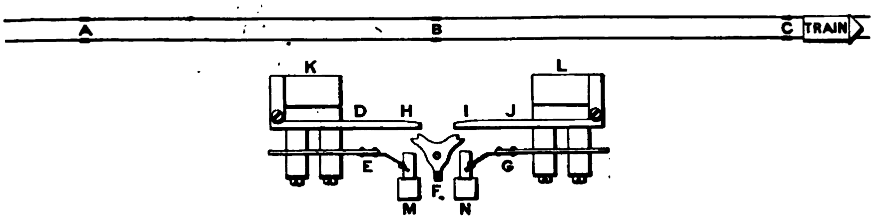


Fig. 594.

Figs. 590-594. Diagrams Showing Operation of Locking Pawl in Interlocking Relay.

Figs. 590-594 illustrate the method of interlocking employed in The Union Switch & Signal Company's relays. To apply this to Fig. 589 it is necessary to consider the pawl inverted and the armatures hinged on the opposite sides at the pole pieces. If the drawing be inverted it will represent the operation of the slate base relay, Fig. 588.

Fig. 590 illustrates the normal condition of the relay, coils energized and armatures picked up. The swinging pawl F is held in place by the weight at its lower end. In Fig. 591 a train has entered the section at A. Arm H has dropped on pawl F, causing it to tilt slightly to the left; contact finger E closes circuit through M to ring the bell. Fig. 592 shows the condition of the apparatus where a train is partly in each section. Both magnets are de-energized, but end of arm I drops into notch of pawl F. This prevents G from making contact at N.

In Fig. 593 the train has passed into the second section. Magnet K has picked up its armature and contacts, but L is still de-energized and I is held by notch in F, so that the bell has stopped ringing. After the train has passed C (Fig. 594), the armature J picks up and the apparatus returns to its normal position.

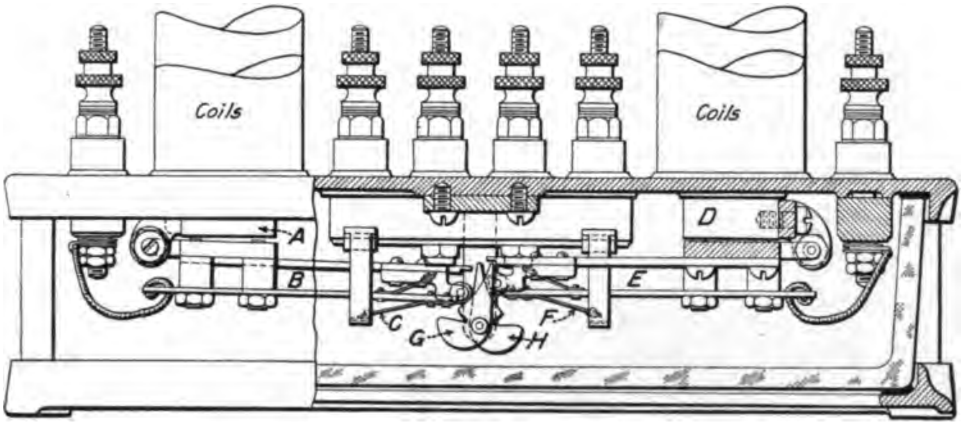


Fig. 595. Enclosed Interlocking Relay. Hall Signal Company.

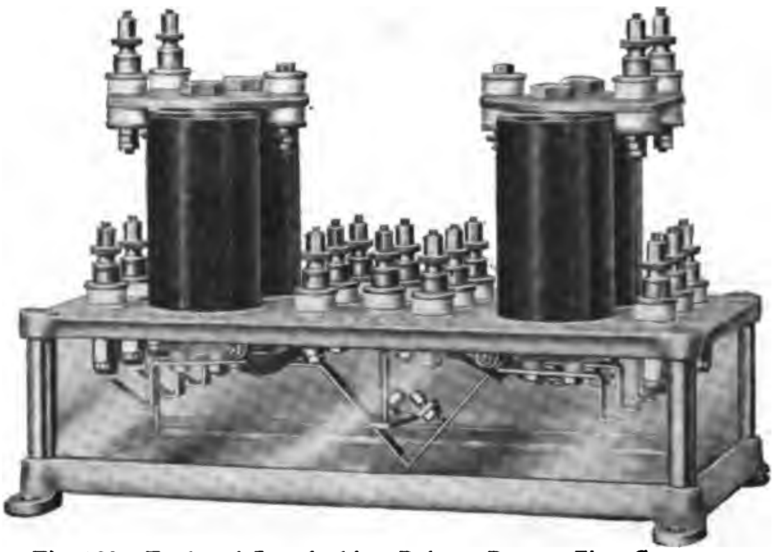


Fig. 596. Enclosed Interlocking Relay. Bryant Zinc Company.

Fig. 595 shows the interlocking relay made by the Hall Signal Company. It consists of two ordinary track relays mounted on the same base facing each other. Each armature carries a projection to which is fastened a lug carrying a roller. Two pawls, G and H, are suspended between the projections. These pawls are pivoted and so counterweighted as to stand normally with their straight sides vertical. In the figure the left-hand armature, B, is shown released. In this position its roller bears against pawl G, forcing its upper extremity under projection on armature E. If the magnet D should be de-energized E cannot drop because it will rest on G, and if A is then energized, raising B, E will still be held up by the pawl G, because the friction between the projection and the dog is sufficient to overcome the effect of the counterweight. When D is again energized the weight of E is removed from G, which at once assumes its normal position. Pawl H acts in like manner on armature B. Each armature is fitted with four front and four back contacts.

The relay shown in Fig. 596 accomplishes the same results as those already described, but in a different manner. The two arms extend diagonally from the armatures, and meeting in the center are so arranged to interlock with each other that when one armature rings the bell the other is not permitted to do so, until both are restored to their normal position. This relay is fitted with three front and three back contacts in addition to the one that rings the bell.

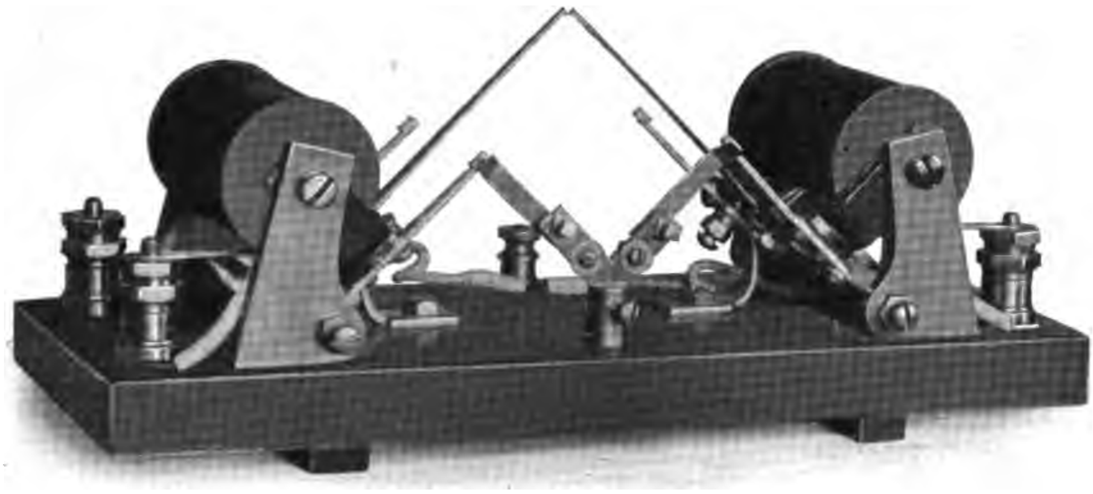


Fig. 597. Slate Base Interlocking Relay. Bryant Zinc Company.

This relay operates on the same principle as the one illustrated in Fig. 596. A distinctive feature is the C-shaped magnets, having but one coil on each.

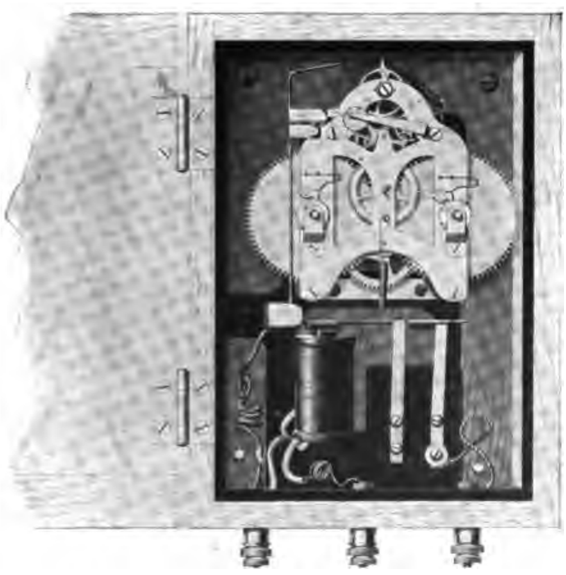


Fig. 598. Escapement Relay, May be Set to Keep Bell Ringing Any Length of Time, from 20 Seconds to 3 Minutes. Railroad Supply Company.

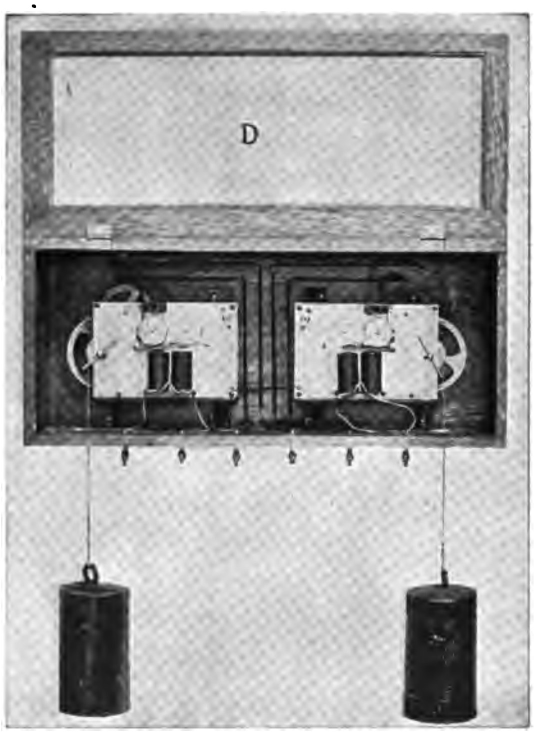


Fig. 599. The O'Neil "Register," a Clockwork Mechanism, Performing the Same Kind of Work as the Relay Shown in Fig. 598. Railroad Supply Company.

In Figs. 598 and 599 the clock work mechanism is actuated by the train passing over a short track circuit or a track instrument (see *Circuit Controllers*) situated at a suitable distance from the crossing. The connection between the starting point and the relay or "register" is made by line wires, and the instrument is set so as to keep the bell circuit closed a predetermined length of time.

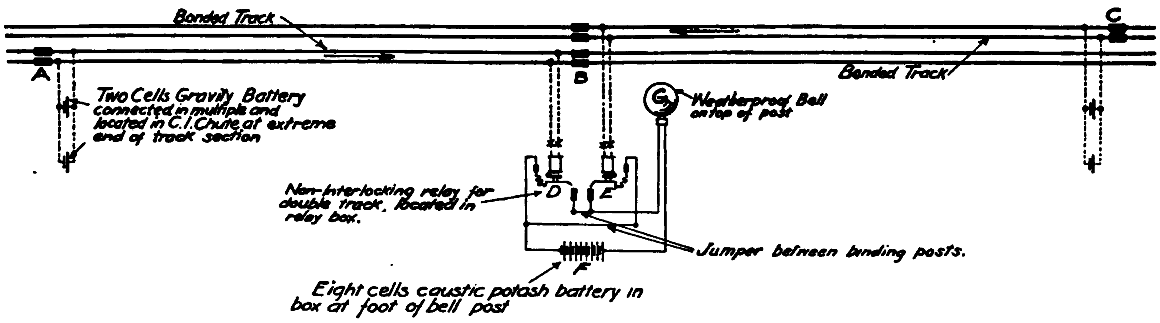


Fig. 600. Arrangement of Apparatus for Double Track Highway Crossing Bell. The Union Switch & Signal Company.

The ordinary bell installation for a double track grade crossing at a street or highway is shown by Fig. 600. A bonded section of track, 1,500 ft. to one-half mile or more, is used on each track in the direction from which trains approach. Insulations are used at the end of these sections as shown at A, B and C. An interlocking relay (with the locking pawl removed) is used to control the local bell circuit. Two ordinary relays would answer as well, but it is sometimes desirable to maintain the interlocking type as a standard for bell work, and it requires somewhat less space. A train entering the ringing sections at A or C will short circuit the coils D or E, respectively, and drop an armature. These armatures carry contact springs that close a local bell circuit on a back contact so that the bell G will ring as long as the circuit of battery F is closed, that is, until the armatures of both D and E are "picked up," which occurs when the train passes out of the sections A to B or C to B. The notations on the cut are self-explanatory.

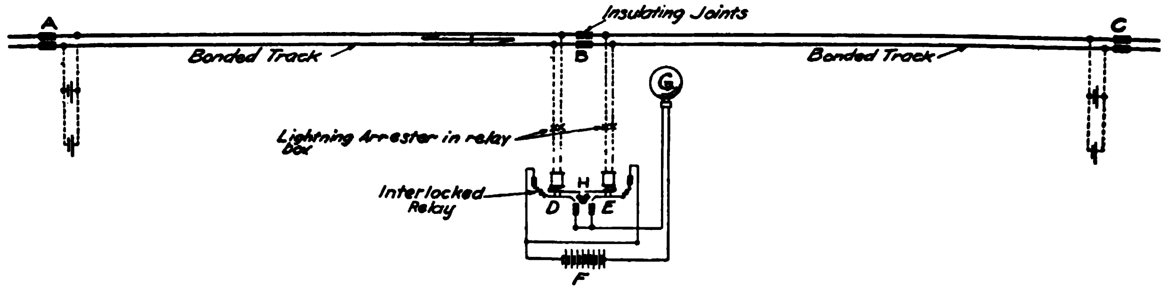


Fig. 601. Arrangement of Apparatus for Single Track Highway Crossing Bell. The Union Switch & Signal Company.

SINGLE TRACK CROSSING BELL LAYOUTS.

A single track crossing bell layout is shown in Fig. 601. As stated in the description of Fig. 600, the track is bonded for 1,500 ft. to one-half mile or more on each side of the crossing from A to B and C to B. As a train enters from either end, the interlocking relay makes back contact on one or the other of the contact fingers attached to the armatures D and E, which completes the local bell circuit of battery F. As it is desired to stop the bell as soon as a train has passed over the crossing, after entering the ringing section, a means must be provided to prevent the armature of that part of the relay controlled from the section beyond the crossing from dropping far enough to make back contact when a train passes the crossing. The locking pawl H is provided for this purpose, as explained in connection with Figs. 588-594. Thus, the bell will ring from the time a train enters the section until it passes over the crossing.

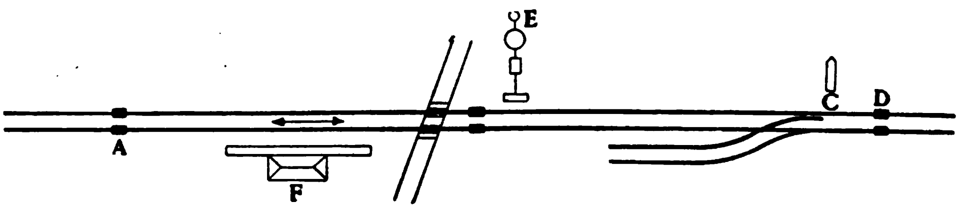


Fig. 602. Special Crossing Bell Layout.

Fig. 602 will serve to illustrate a number of special conditions under which it is advisable to use special keys in addition to the standard layout, in order to stop and start a crossing bell in connection with certain train movements as a means of preventing false alarms and continuous ringing. The additional apparatus required will be a relay at the crossing and two keys located so that they will be convenient to trainmen or operators. The momentary closing of either key contact cuts the bell out or in, it not being necessary to retain the finger on the key for more than an instant. In connection with this feature it should be understood that only when a train is on the track section approaching the crossing can the bell be manually cut out. It may again be cut in, when it will ring until the train passes over the highway; or should the operator neglect to cut the bell in, the train will automatically perform this operation in passing out of the bonded sections, and restore the instruments to their normal positions so that the bell will again ring for the next approaching train. The following examples will illustrate a few of the conditions met in actual practice and will give an idea of the many instances where a highway crossing bell can be used successfully and to advantage at points where the track layout or switching conditions are somewhat complicated:

Case 1. If an approaching train enters the bonded section at A and stops at Station F the bell E at the highway would ordinarily ring during the time that stop is made and until the train again proceeds and passes beyond the crossing. In consequence, the bell is ringing during the time that train is at a stop, and the street is open to the safe passage of the public. If such a condition is allowed to continue, the bell ceases to become a warning and is locally classed as a public nuisance. A stop and start key is installed in the station. Under these conditions the agent presses the stop key when the train slows down and the bell consequently ceases to ring. If the crossing is very close to the station no starting key is required, for the train may proceed slowly over the crossing with the engine bell ringing, and in passing beyond the crossing the bonded sections will automatically restore the instruments, as before stated. Should the crossing be some distance from the station, however, the agent may press a starting key when the train is ready to proceed, and give the proper warning at the highway. In this latter instance of course the bell will stop ringing when the entire train has passed over the crossing.

Case 2. Referring to the same layout, should F be a day station only, or for any reason should it be undesirable for the agent to handle operating keys, the same results may be obtained as outlined in Case 1, by inserting short one-rail sections in the track circuit approaching the crossing in lieu of the keys, and thereby make the cut-in and cut-out feature dependent entirely on the location of the engine relative to the crossing; or a train in coming to a stop at the station passes onto a stop section and automatically cuts the bell out of circuit. When the same train again proceeds the engine enters

a starting section located at a specified distance from the crossing and bell again rings, it being understood that the stop and start sections are such a short distance apart that a through train approaching the crossing at speed will give practically a continuous warning, as its effect in passing over the cut-out and cut-in section will cause no noticeable interruption to the bell circuit.

Case 3. Should the approach section to a bell include a switch as shown at C (Fig. 602), it is advisable to provide a stop and a start key at such a switching point for the convenience of trainmen in controlling the ringing of the bell while switch is being used and cars are being switched on and off the bonded section. The keys are usually placed in a shelter and mounted upon a post adjacent to the switchstand. Keys at C and F, or at a number of different points may be used to control the same bell without in any way conflicting with its operation.

Case 4. Should C (Fig. 602) be a switch leading to a passing siding or at the end of a double track, it may be readily seen that a train coming on to main line at C and proceeding toward D will give a false alarm at the crossing during the time that section CD is occupied. This situation can be properly protected so that bell will not ring for a train entering CD from the siding, provided the train proceeds in a direction away from the crossing. Should, however, a train clear the switch and run toward the highway a sufficient warning will be given.

Figs. 606-607 illustrate circuits used to cover some of the conditions mentioned above.

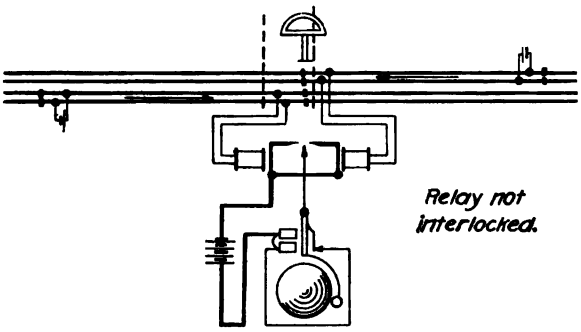


Fig. 603. Crossing Bell Circuits, Double Track. Railroad Supply Company.

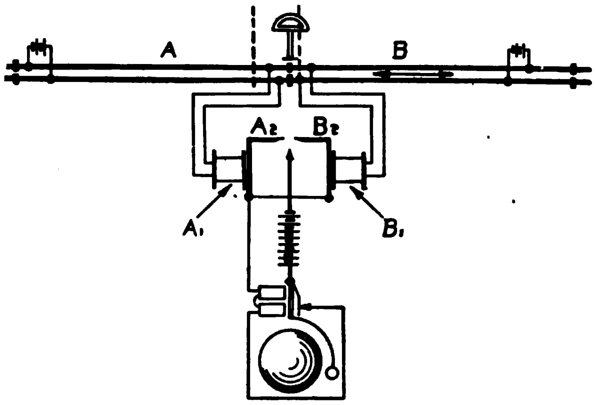


Fig. 604. Crossing Bell Circuits, Single Track. Railroad Supply Company.

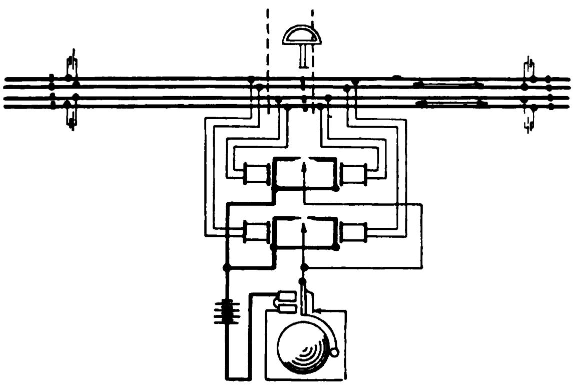


Fig. 605. Crossing Bell Circuits, Two Single Tracks. Railroad Supply Company.

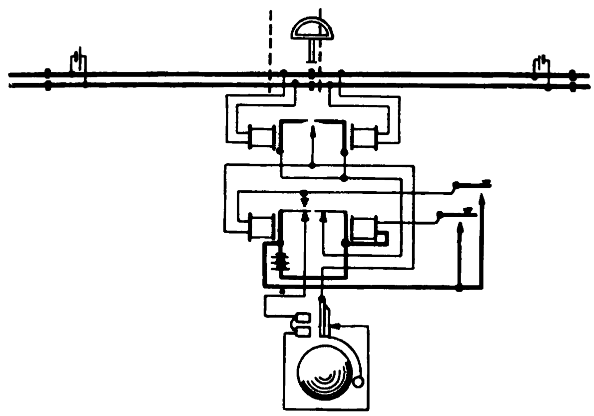


Fig. 606. Crossing Bell Circuits, Single Track, with "Cut-out" and "Cut-in" Keys. Railroad Supply Company.

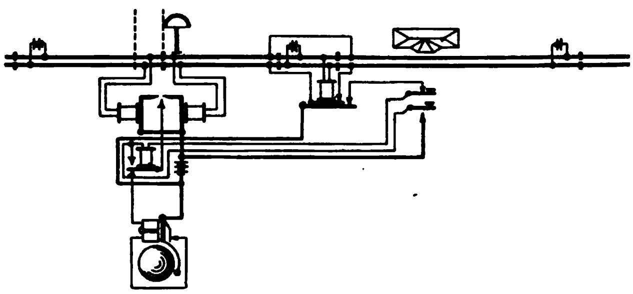


Fig. 607. Crossing Bell Circuits, Single Track, Automatic Starting Section, with "Cut-out" and "Cut-in" Keys. Railroad Supply Company.

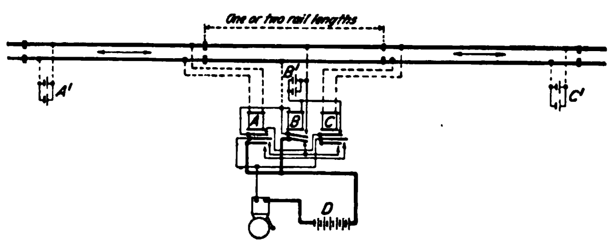


Fig. 608. Single Track Crossing Bell Circuits, Without Interlocking Relay. Delaware, Lackawanna & Western.

Fig. 603 shows the circuits for a double track crossing bell, using the relay shown in Fig. 586, but with fingers so arranged as not to interlock. A train in either section shunts the relay magnet, allowing its finger to make contact with back point, thereby establishing a circuit through the bell.

Fig. 604 shows the circuits for a single track crossing bell, using the relay shown in Fig. 586. A train in either section affects the relay as in Fig. 603, but when it passes from one section to the other, the magnet of the first section picks up, raising both metal strips and thereby stopping bell.

Fig. 605 shows two single track installations operating one bell in common. The circuit arrangement is an adaptation of Fig. 604.

Fig. 606 shows a device for stopping the bell while a train is in the initial section and for starting it again if so desired. The relays are similar to the one shown in Fig. 586. A train in either section de-energizes one or the other of the magnets of upper relay completing a circuit from the top cell of battery through the back point of the left-hand side of the lower relay, bell, back point of upper relay, finger, back right-hand point and finger of lower relay, back to battery. The lower relay is normally de-energized and is not interlocked. If desired to stop the bell, the upper key is pressed down. This completes a circuit from battery, through key, left-hand magnet of lower relay, back point and finger of upper relay, back point and finger of right-hand magnet of lower relay to battery. This energizes the left-hand magnet of the lower relay which picks up its armature and breaks the bell circuit. At the same time it establishes a "stick" circuit through its front point, thereby keeping itself energized while the train remains in the section. To start bell again, the lower key is pressed which energizes right-hand magnet of the lower relay opening the "stick" circuit and de-energizing the left-hand coil. Releasing the lower key restores the lower relay to its normal condition, and the bell rings until the train has passed out of the section, as in Fig. 604. The "stick" circuit is

broken in any event when the train leaves section. This arrangement is used where much switching is to be done on the track circuit.

Fig. 607 shows circuit to accomplish same results as Fig. 606, except that the bell starts automatically when train reaches the short independent track circuit. The "stick" relay is energized by pressing the lower key, and de-energized by pressing the upper key, or by the opening of the track relay in the short section. This relay also breaks the circuit for the bell track section proper, thereby assuring continuous ringing under normal operation. This arrangement is used where trains make a station stop on a crossing bell track circuit.

Fig. 608 shows how a single track crossing bell may be operated without an interlocking relay. Suppose a train enters the section at battery A′. Relay A will be de-energized and cause the bell to ring through a circuit from battery D, through bell, middle back contact of relay A, back contact of relay B, to battery. When the train enters the short middle section relay, B picks up and opens the bell circuit. Relay A also picks up when train has left its section. Relay B is a "stick" relay and, when energized, closes its own circuit from battery B′ through front point and coil of relay B, back to battery B′, when either A or C are de-energized. When the train enters the section C, the bell does not ring as its circuit remains broken by relay B. When the train passes battery C′, relay C picks up and shunts relay B by a short circuit from battery B′, through front point of relay B, front points of relays A and C to battery B′. This de-energizes relay B and restores the apparatus to its normal condition. Suppose while the first train was in track circuit C a second train should enter track circuit A. Relays A and C would both be de-energized and relay B energized. The bell would ring for the second train by a circuit from battery D, through the lower bell, lower back contact of relay C, lower back contact of relay A, back to battery D.

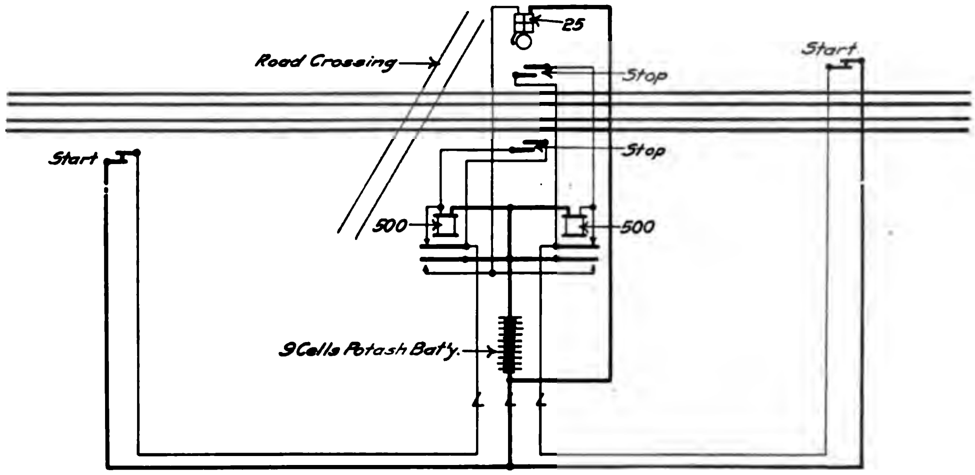


Fig. 609. Normally Closed Line Circuits for Double Track Crossing Bell, with Track Instruments.

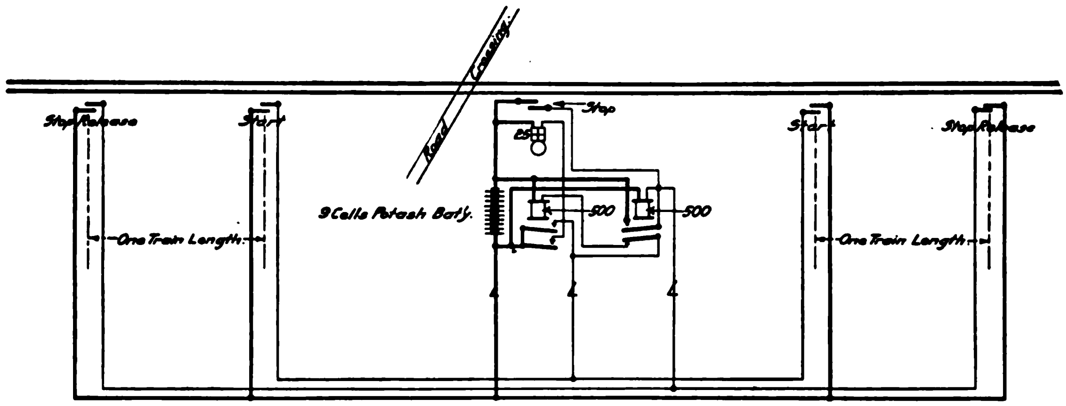


Fig. 610. Normally Open Line Circuits for Single Track Crossing Bell, with Track Instruments.

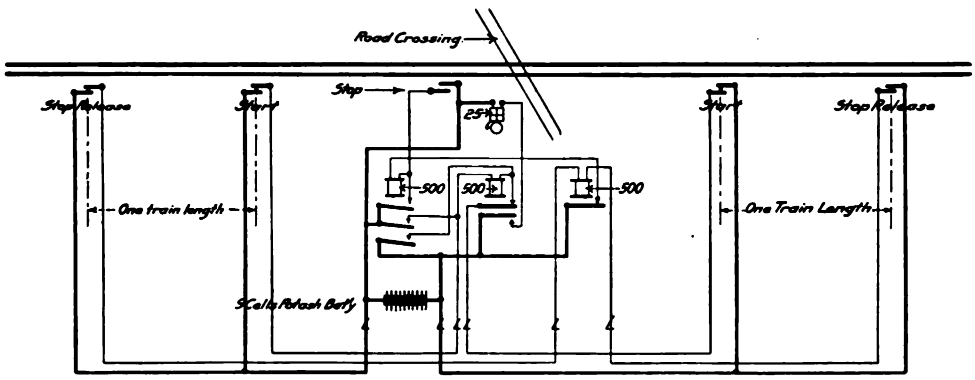


Fig. 611. Normally Closed Line Circuits for Single Track Crossing Bell, with Track Instruments.

Fig. 609 shows double track crossing bell circuits using track instruments or "trips." A train passing over either instrument marked "start" will open the circuit of the 500-ohm relay with which it is connected, de-energizing the relay and closing the bell circuit. The relay breaks its own circuit and the bell continues to ring until instrument marked "stop" is depressed, when the relay is again energized and completes the original "stick" circuit through its own armature and the starting instrument.

Fig. 610 shows single track crossing bell circuits using track instruments with relays normally de-energized. The depression of a starting instrument energizes left-hand relay, which closes its own circuit through one front point and the bell circuit through the other. The "stick" circuit holds until the train reaches the crossing. Depressing the stopping instrument energizes the right-hand relay which breaks the circuit for the first relay, stopping the bell, and closes its own circuit through a front point. Now depressing either starting instrument has no effect, but depressing either "stop release" instrument shunts the right-hand relay and restores the apparatus to its normal condition.

Fig. 611 shows single track crossing bell circuits using track instruments, with control relays normally energized. Depression of either starting instrument breaks "stick" circuit of middle relay, which rings the bell through its back contact. Depressing the "stop" instrument picks up the left-hand relay. This relay "sticks" through one front point and closes the circuit for middle relay through the other two. Depressing either starting instrument will now have no effect, as they are both shunted out, but depressing either "stop release" instrument momentarily breaks the circuit of right-hand relay, which opens the circuit of the left-hand relay, thereby restoring the apparatus to its normal condition.

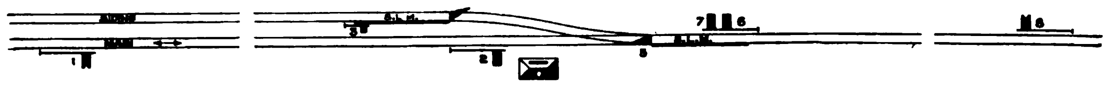


Fig. 612.

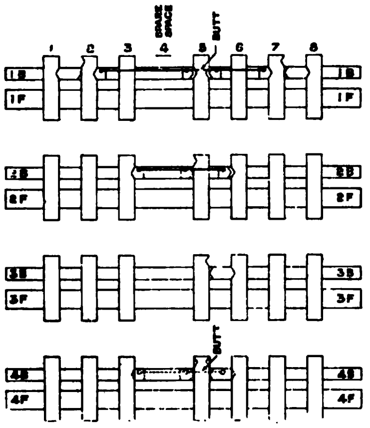


Fig. 613. "Standard" Dog Chart.

REVERSE	LOCKS
1	2
2	5-7
3	5-6
4	SPARE SPACE
5	
6	5
7	5
8	7

Fig. 614. Locking Sheet.

MACHINE

6 LEVERS FOR 6 SIGNALS
1 LEVER FOR 1 SWITCH AND 1 DERAIL
7 WORKING LEVERS
1 SPARE SPACE: 4
8 LEVER FRAME

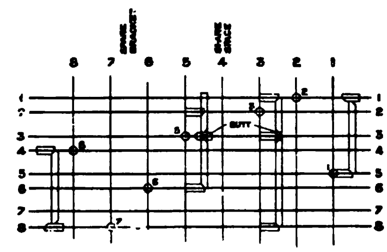


Fig. 615. "Saxby & Farmer" Dog Chart.

Figs. 612-615. Interlocking Plan, Locking Sheet and Dog Charts; Single Track and Turnout.

INTERLOCKING

The concentration of a considerable number of switch or signal levers in the hands of one man would naturally result in the operator at some time mistaking the lever which he was to throw. Through such an error a train might be derailed or diverted from its proper course, or a signal permitting a certain movement might be displayed at the same time another signal permitting a conflicting movement was given. To prevent occurrences of this kind the various levers operating a number of switches and signals placed together in one bank or stand are so interconnected that only proper and non-conflicting movements can be made. This interconnecting of devices used to operate switches or signals so that their movements can only occur in predetermined sequence is called "Interlocking," and the assemblage of the necessary stands, levers and connections between the levers is called an "interlocking machine."

The manner in which the interlocking of the levers is accomplished may be understood by reference to Figs. 612-615, which show a track layout and the locking sheet and dog charts. The dog chart is the working drawing by which the locking is laid out and is a miniature diagram of the locking as it appears in the machine.

The interlocking plan illustrated in Figs. 612-616 shows a single-track layout, with one siding. A derail is placed at the fouling point on the siding to prevent a car or train on the siding from coming out where it would collide with a train on the main line. The derail and the switch are operated by one lever, No. 5. A dwarf signal is located approximately 55 feet back of the derail to control movements from the siding. Home signal 2, which is located at the fouling point of the two tracks, protects movements over switch 5. It is placed so as to permit a movement to or from the siding while a train is standing at (in the rear of) it. No. 1 is a distant signal for home signal 2 and is located a sufficient distance in the rear of 2 to enable an engineman to get his train under control before he reaches the home signal, if the distant signal should indicate "caution" when he passed it. Levers 6 and 7 control a two-arm home signal placed about 55 feet back of the switch point. Lever 7 operates the top arm which governs movements on the main line, and lever 6 the lower arm for movements from the main track to the siding. No. 8 is the distant signal for home signal 7.

The different functions are so connected that when the signalman is operating levers at one end of the machine, the signals, etc., operated will be located at the corresponding end of the interlocking plant. The heavy black line in the tower designates the position of the machine and the dot represents the signalman. These positions should be determined before proceeding to allot numbers to the levers controlling the various functions. When numbering a signaled layout, such as shown in Fig. 612, it is the practice first to number the high signals, then the dwarf signals, for movements in one direction; then part of the spare spaces or levers, if any; then the switches, derails and facing point locks; then the remaining spare spaces or levers; and, finally, the signals for movements in the opposite direction.

In Fig. 614 is shown a locking sheet for the interlocking plant illustrated in Fig. 612. Before proceeding to make this locking sheet, the routine of the various signals should be determined. When an engineman passes a clear distant signal it indicates a clear route through the interlocking. Therefore, the reversal of lever 1 controlling the distant signal should lock home signal lever 2 reversed and 2 reversed should lock switch and derail lever 5 normal, so that switch 5 and home signal 2 will be in their correct positions for a through movement from distant signal 1. Home signal lever 2 reversed should also lock home signal lever 7 normal to prevent the clearing of the two conflicting home signals, 2 and 7, at the same time. Dwarf signal lever 3 reversed should lock switch and derail lever 5 reversed, as the derail should be closed and the switch reversed before a train is allowed to proceed over them. Dwarf signal 3 reversed should also lock home signal lever 6 normal to prevent dwarf signal 3 and home signal 6 from being both in the clear position at the same time. Home signal lever 6 reversed should lock 5 reversed so that switch and derail controlled by lever 5 will be in the correct position for a movement from the main line to the siding. Home signal lever 7 reversed should lock switch and derail lever 5 normal, so that the derail will be open and the switch in the correct position for a movement on the main line. Lever 8 reversed should lock lever 7 reversed, which lever controls the high speed arm of the two-arm home signal, so that when distant signal 8 is in the clear position, derail 5 will be open, switch 5 will be set for the main line and home signal 7 will be in the clear position, thereby setting up a clear route from the distant signal through the interlocking. With all signals normal, lever 5 may stand normal or reversed, the position of switch and derail controlled by that lever being, under these conditions, immaterial. It is apparent that if any of the signals are in the clear position it would be impossible to reverse lever 5, because it would be locked in one position or the other by the reversal of the signal lever. If a train is making a movement on the main line, another train cannot leave the siding, as 5 would be locked normal by 2 or 7 reversed, it being impossible for the signalman to reverse lever 3 unless 5 is reversed. Again, if a train is making a movement to or from the siding, it is impossible to reverse lever 2 and give a clear home signal, as this lever calls for 5 in the normal position and lever 5 would necessarily have to be reversed for the movement to or from the siding.

The locking sheet shows that 2 reversed locks 7 normal, which is the same as 7 reversed locks 2 normal (see dog chart, Fig. 613). This condition prevails in all cases where one lever reversed locks another lever normal, the first lever that is reversed locks the other lever in the normal position.

Before proceeding to make a dog chart it is necessary to ascertain from the locking sheet whether or not any two or more levers lock any other lever or levers in certain positions. Very frequently dogs may be grouped together on one locking bar, thereby economizing space and material, and it is very often possible, by means of a butt, to avoid duplication of locking bars for the reason that if this were not done two sets of dogs performing exactly the same functions, but using two separate bars and occupying two spaces in the locking frame, would be required. For instance, 2 and 7 reversed lock 5 normal. This is also true of levers 3 and 6 which, when reversed, lock 5 reversed, but it is inadvisable to follow the above method in this particular case, as the butt would have to be placed between dogs on either side of tappet 5, as shown dotted, in the fourth space, and this would leave a very short piece of bar on the double dog to the right of tappet 5, which would be likely to twist to one side and make the butt ineffective. Of course, if cramped for space in a machine, the short bar referred to can be extended to the right and a guide dog fastened to its end. This construction would make such an arrangement satisfactory.

In the locking sheet lever No. 5 is shown as performing no locking function, but an inspection of the sheet shows that this lever occurs in four combinations, namely 2, 3, 6 and 7 and, if it were desirable, it could be stated in the sheet that lever 5 reversed locks 2 normal and 7 normal; also when 5 is normal it locks 3 and 6 normal; but this is not done as it would be merely a restatement of

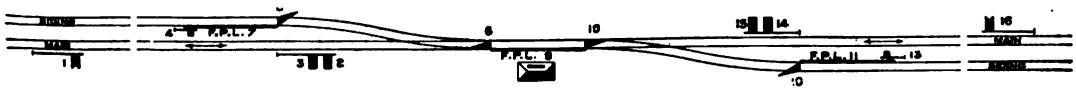


Fig. 616. Interlocking Plan; Single Track, Two Turnouts.

MACHINE

8 LEVERS FOR 8 SIGNALS
2 " " 2 SWITCHES AND 2 DERAILS
3 " " 4 F.P.Ls.
13 WORKING LEVERS
1 SPARE SPACE: 5.
2 " LEVERS: 6. 12
16 LEVER FRAME

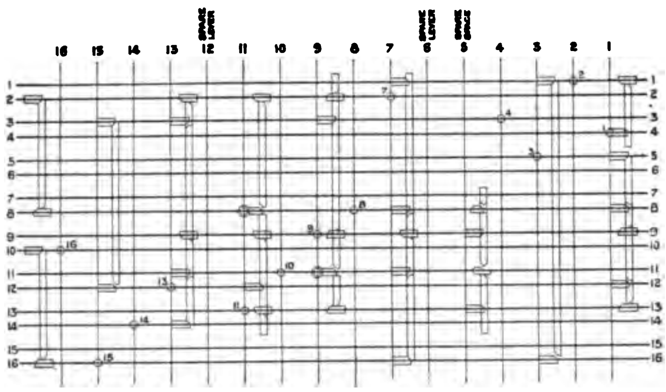


Fig. 617. Dog Chart for Fig. 616; Saxby & Farmer Machine.

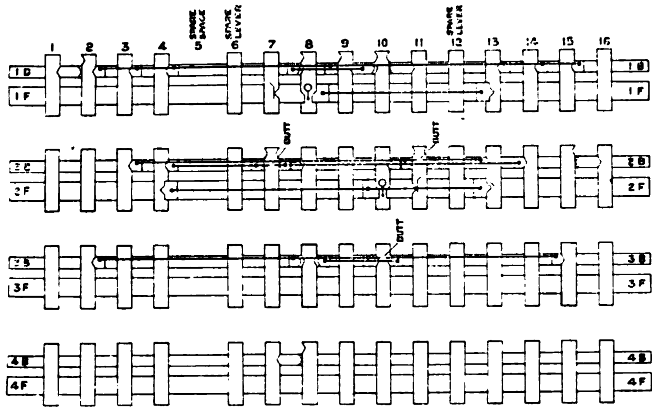
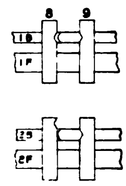


Fig. 618. Dog Chart for Fig. 616; Standard Machine.

REVERSE	LOCKS	REVERSE	LOCKS
1	2	9	8-8-10-10
2	8-9-10-15	10	
3	8-9-11-13	11	10
4	7-9-14-13	12	SPARE LEVER
W	10 × 11	13	11-9
5	SPARE SPACE	W	8 × 7
6	SPARE LEVER	14	10-9-7
7	8	15	10-9-8
8		16	15

Fig. 619. Locking Sheet for Fig. 616.



Figs. 620-621. Details of Locking; Standard Machine.

what is already shown. In the same manner it might be said in the locking sheet that lever 7 reversed locks lever 2 normal. The locking sheet is made up as a guide to the preparation of the dog chart, and everything that appears in the locking sheet should appear in the dog chart. If the repetitions as above stated should appear in the locking sheet, they would appear in the dog chart as unnecessary or overlocks. They are, therefore, omitted.

Interlocking plan shown in Fig. 616 differs from that illustrated in Fig. 612 only to the extent of an additional siding connecting with the main line. The signaling necessary to cover this addition is worked out on the same basis as the scheme employed for the single turnout, with the exception of the facing point locks, which have been substituted for switch and lock movements. This necessitates a slight variation in locking because the facing point lock levers, when reversed, lock the switches either normal or reversed. It is necessary with this arrangement of tracks to make the home signal 2-3 a two-arm signal. The top arm 2 governs movements on the main line, over switches 8 and 10 normal, the lower arm 3, movements to the siding, over 8 normal and 10 reversed.

Notice should be given to the method of numbering the facing point locks, derails and switches. First is facing point lock 7, locking derail 8; then facing point lock 9, locking switches 8 and 10; and, finally, facing point lock 11, locking derail 10. This arrangement of levers insures a good run of the connections operating the facing point locks, switches and derails. It also brings next to one another the levers which are to be operated consecutively; for instance, when a signalman throws switch 8 or 10, he must then throw facing point lock lever 9 to lock it. Furthermore, it simplifies, to a certain extent, the arrangement of the locking on the dog chart.

As shown on the plan, derail and switch 8 are operated by one lever, as it is always necessary to have both either normal or reversed at the same time. Lever 10, controlling switch and derail, is a similar instance. As it is always necessary to use 9 when either 7 or 11 is being used, it is possible to operate either 7 and 9, or 9 and 11, with one lever; but this is not advisable. With the arrangement as shown it is impossible to reverse 7 unless 8 is reversed. This is also the case with 11 and 10. Therefore, if 7 and 9 were operated by one lever, it would be necessary to lock both the derail and switch 8 in both normal and reversed positions, with this lever. The undesirable feature is this: If the signalman started to reverse switch and derail 8, and the connections between the lever and derail should become disconnected before the derail had started to move, he might complete the reverse movement of lever 8 and leave the derail open without knowing it. He could then reverse 7 (the plunger returning into the same hole in the derail lock rod from which he had just withdrawn it) which would permit him to clear signal 4. A train from the siding would then proceed and be derailed. One spare space, 5, and two spare levers, 6 and 12, have been provided to take care of future changes.

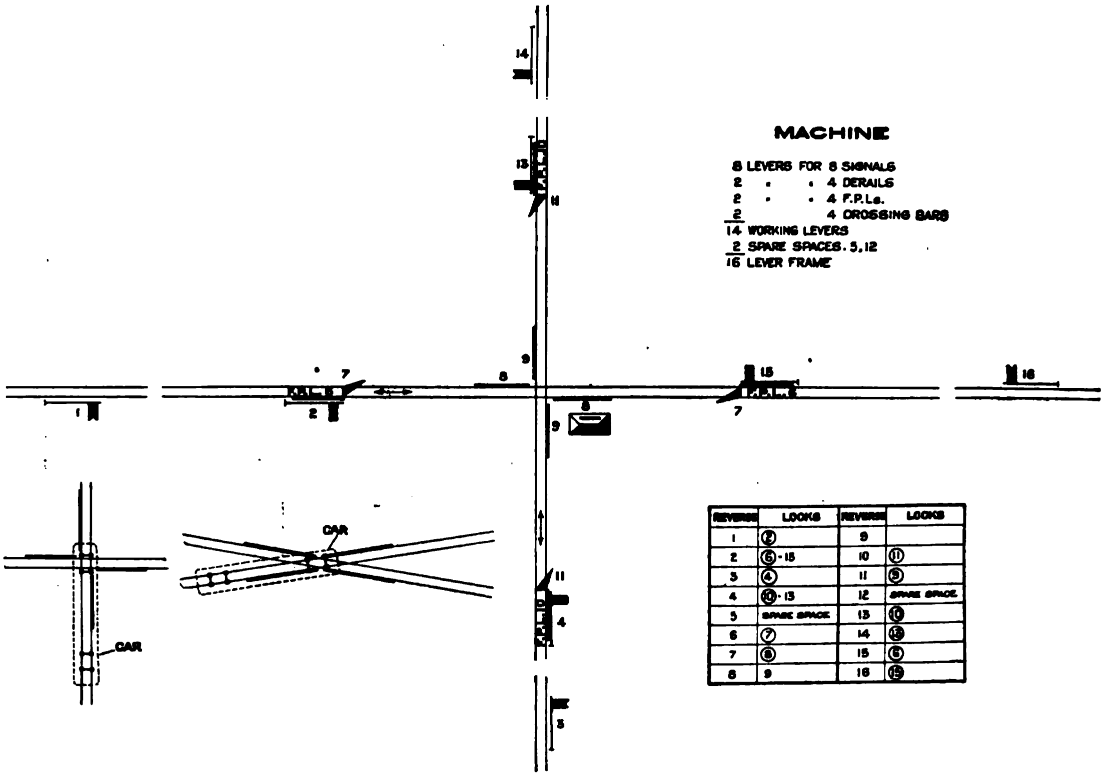
Such points in the locking sheet (Fig. 619) as differ from locking sheet, Fig. 614, will be now explained. Lever 2 reversed locks 8 and 10 normal; it also locks 9 reversed, which in its turn locks 8 and 10 in their normal and reversed positions, both in the locking in the machine and on the ground. Lever 3 reversed does not lock 10 reversed direct, but 10 is locked reversed by 11 reversed, which in its turn is locked by 3 reversed. Lever 4 reversed locks 7 reversed, which in turn locks 8 reversed; therefore, it is not necessary for 4 reversed to lock 8 reversed direct as it does this indirectly through 7.

As it is possible to make a movement from signal 4 to either the main line or opposite siding, a special condition arises in connection with the locking. It is evident that the only time that 11 should be reversed is when a movement is to be made over 10 reversed; therefore the locking would read "4 reversed, when 10 is reversed, locks 11 reversed." (See dog chart, Fig. 618, which illustrates this and also shows that 11 would remain unlocked with 4 reversed if 10 were normal.)

When making dog charts it is not the practice to indicate in full the tappet pieces (numbers 9A, etc., Figs. 729-770), as the front dogs used in connection with them indicate which tappet pieces are employed. The special on lever 13 in connection with levers 7 and 8, is similar to the special on lever 4. Lever 14 reversed does not lock 8 reversed direct, as 8 is locked reversed by 7 reversed, which is in turn locked by 14 reversed. If the locking sheet had shown 14 reversed locking 8 reversed, it would have been called an "overlock." This is a duplication of locking already accomplished.

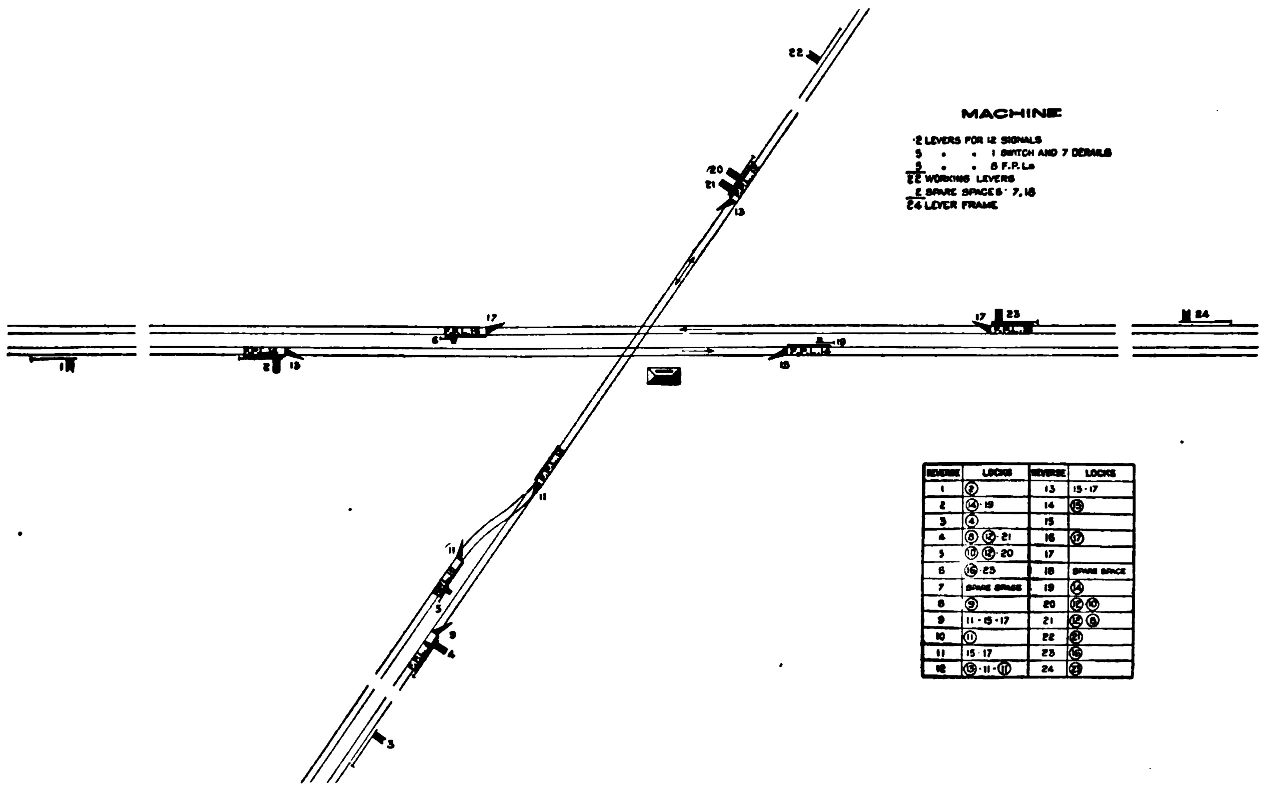
It will be noticed that in the Standard* dog chart (Fig. 618), levers

*See definition of *Standard Interlocking Machine*. This machine is referred to in this manner throughout this description.



REVERSE	LOCKS	REVERSE	LOCKS
1	2	9	
2	6 - 15	10	11
3	4	11	9
4	10 - 13	12	SPARE SPACE
5	SPARE SPACE	13	10
6	7	14	13
7	8	15	6
8	9	16	15

Figs. 622-625. Typical Interlocking Plan and Locking Sheet; Single Track Crossing, Showing the Use of Crossing Bars.

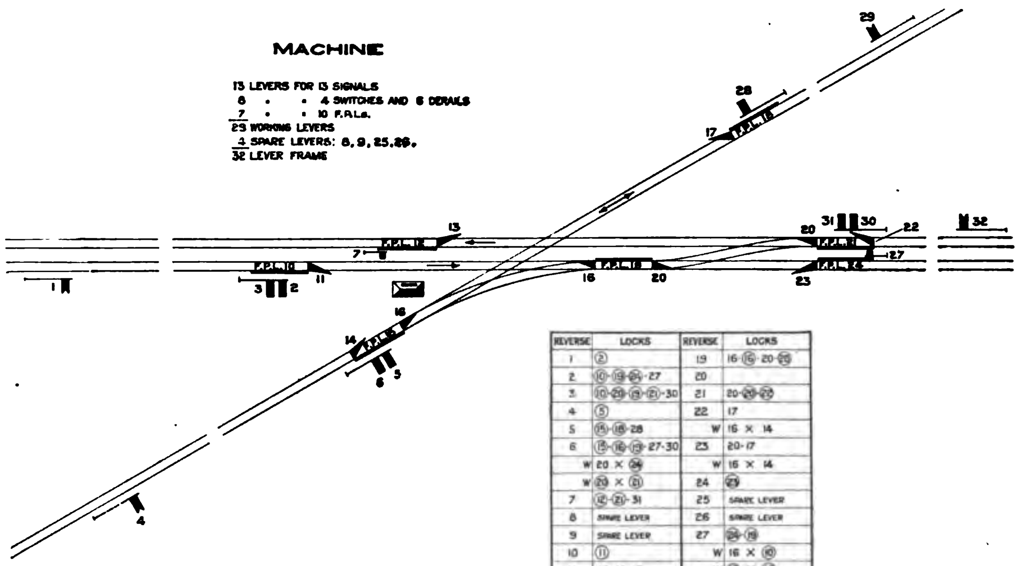


REVERSE	LOCKS	REVERSE	LOCKS
1	2	13	15 - 17
2	14 - 19	14	15
3	4	15	
4	8 12 - 21	16	17
5	10 12 - 20	17	
6	16 - 23	18	SPARE SPACE
7	SPARE SPACE	19	14
8	9	20	12 10
9	11 - 15 - 17	21	12 8
10	11	22	21
11	15 - 17	23	16
12	13 - 11 - 11	24	23

Figs. 626-627. Typical Interlocking Plan and Locking Sheet; Single Track (with Turnout) Crossing Double Track.

2, 3, 4, 13, 14 and 15 lock 9 reversed, using only one bar. When combinations of this description are possible they simplify the locking by eliminating a number of dogs and bars that otherwise would be necessary. If one lever reversed locks another lever normal and reversed; for instance, 9 reversed locks 8 normal and reversed, the locking should be arranged as shown in the dog chart and not separated, as shown in Figs. 620-621. The latter arrangement would make it impossible to reverse 9 whether 8 were normal or reversed. Regarding the arrangement of back locking in the third space of dog chart, Fig. 618, it will be seen that 2 reversed locks 8 and 10 normal. The bar then butts against the top bar to the right of it, consequently holding the dog in the notch of tappet 15 and thereby locking it normal. Furthermore, when 15 is reversed it locks 10 and 8 normal, as the first and second bars are both fastened to the same dog.

The combinations of locking used in making the Saxby & Farmer dog chart (Fig. 617) as shown are considerably different from those found to give the best results with the Standard, this being due to the different construction of the locking. When preparing to lay out a Saxby & Farmer dog chart for the locking sheet shown in the figure,



REVERSE	LOCKS	REVERSE	LOCKS
1	2	19	16-16-20-20
2	10-19-24-27	20	
3	10-20-19-21-30	21	20-20-20
4	5	22	17
5	15-18-28	W	16 × 14
6	15-16-19-27-30	23	20-17
W	20 × 24	W	16 × 14
W	20 × 21	24	29
7	12-21-31	25	SPARE LEVER
8	SPARE LEVER	26	SPARE LEVER
9	SPARE LEVER	27	24-19
10	11	W	16 × 10
11	16-14-17	W	16 × 15
12	13	28	18-15
13	20-17	29	29
W	16 × 14	30	21-28-19
14		W	16 × 10
15	14-16-16	W	16 × 15
16		31	21-12
17	16	32	31
18	17		

Figs. 628-629. Interlocking Plan and Locking Sheet; Single Track Crossing Double Track, with Connecting Track and Crossover.

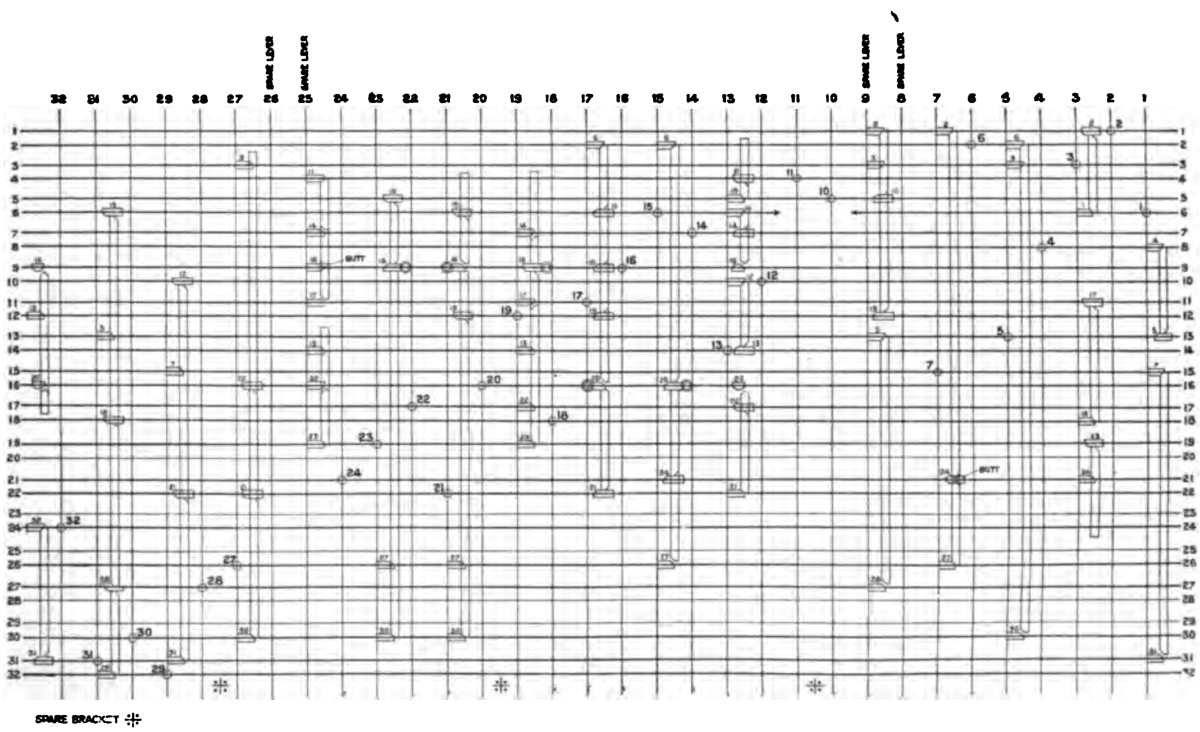


Fig. 630. Saxby & Farmer Dog Chart for Figs. 628-629.

the best method of procedure, after becoming familiar with the locking sheet, is first to lay out the locking for the levers on which specials occur. Reference to the locking sheet will show that lever 4 reversed when 10 is reversed locks 11 reversed. Therefore, it is advisable to place the driver operated by lever 4 on one of the bars near the top of the chart; next in order should come driver for lever 10; then for 11. After the drivers have been located for levers 4 and 13, the special locking for these levers should be laid out. This will then give an idea of where the rest of the drivers should be located to give the best results.

Figs. 636-637 show typical signaling for the control of a double track drawbridge. The derails for high speed movements are placed about 500 ft. from the draw and those for reverse movements about 300 ft. It is advisable, at drawbridges, to control the facing point locks and the derails each with a separate lever, as it insures easier and somewhat safer operation. It is apparent that when the draw is opened the connections which operate the various functions must be disconnected to allow the bridge to swing. This is accomplished by couplers operated by lever 11 which, when reversed, make a through connection from the levers to the functions. The rail locks, operated

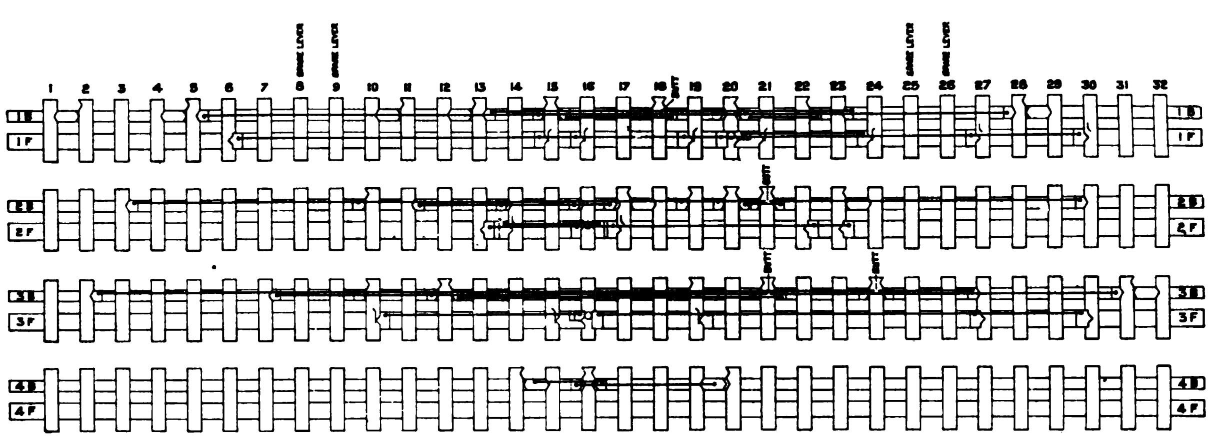
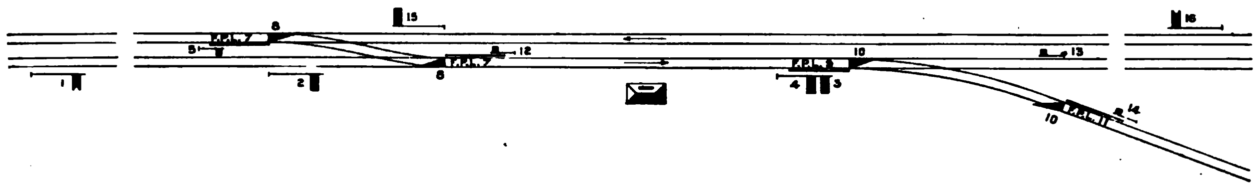


Fig. 631. Standard Dog Chart for Figs. 628-629.

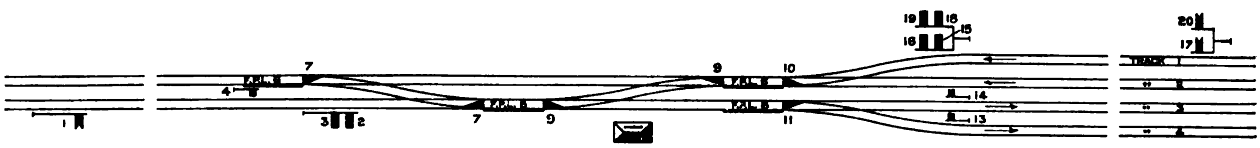


MACHINE

10 LEVERS FOR 10 SIGNALS
2 " " 3 SWITCHES AND 1 DERAIL
3 " " 4 F.P.Ls
15 WORKING LEVERS
1 SPARE SPACE: 6
16 LEVER FRAME

REVERSE	LOCKS	REVERSE	LOCKS
1	2 3	9	10 10
2	8 7 12 13 14	10	
3	9 10 13	11	10
4	9 11 14	12	7
5	7 15	13	10 9
W	8 X 12·13 14	14	11 9
6	SPARE SPACE	15	8 7
7	8 8	16	15
8			

Figs. 632-633. Typical Interlocking Plan and Locking Sheet; Single Track Junction with Double Track.



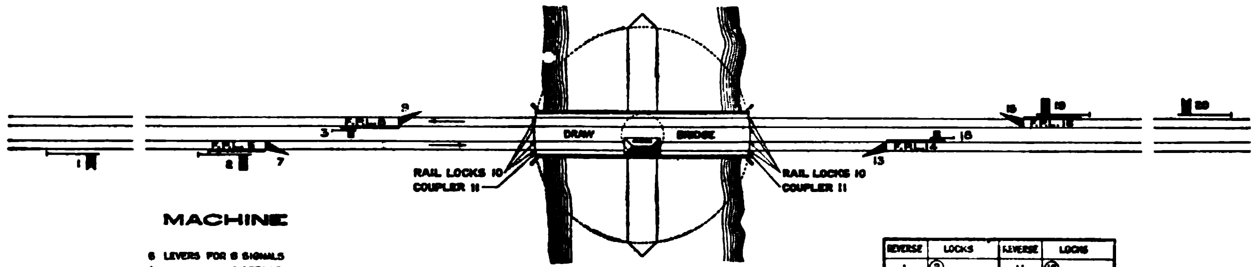
MACHINE

12 LEVERS FOR 12 SIGNALS
4 " " 6 SWITCHES
2 " " 6 F.P.Ls
18 WORKING LEVERS
2 SPARE LEVERS. 5, 12
20 LEVER FRAME

REVERSE	LOCKS	REVERSE	LOCKS
1	2	W	9 X 7
2	7·8·9·11·14	11	9
3	7·8·13·15·18	12	SPARE LEVER
W	9 X 11	13	11·8
W	9 X 6	W	7 X 6
4	6·15·16·18·19	14	11·8·9
W	7 X 9	W	7 X 6
W	7 X 8·13·14	15	10·[illegible]·9·6
5	SPARE LEVER	16	10·6·9·7
6	7·7·9·9·10·10	17	16
7		18	10·6·9·8
8	7·7·9·9·11·11	19	[illegible]·6·9
9		20	13
10			

Figs. 634-635. Typical Interlocking Plan and Locking Sheet; Double Track to Four-Track Junction.

by lever 10, are arrangements which require the rails to be in a correct position for a movement over them, before the lever operating the rail locks can be reversed, which, indirectly, allows the derails to be closed. "Starting" or bridge locking lever 12 is so interlocked with the operating mechanism of the drawbridge that it is impossible to operate the draw until 12 is reversed, and lever 12 cannot be returned to its normal position until the drawbridge is closed. The action of reversing 12 indirectly locks all the derails in their normal positions. The derail levers 7, 9, 13 and 15 cannot be reversed until 11 is reversed, as lever 11 couples the connections operating the apparatus, as explained. It is apparent that these connections should not be coupled until the rails are locked in the proper position for a movement over them. Therefore, 11 reversed locks 10 reversed which, in its turn, locks 12 normal, preventing the opening of the drawbridge. Should a movement be made from signal 2, over the drawbridge, the following procedure would be necessary on the part of the signalman. He would first ascertain that 12 was in the normal position to insure that the draw was locked. This would allow him to reverse 10, thereby locking the rails. He could then reverse 11, which would couple the connections and unlock derails 7 and 13, which he could then reverse; next would follow the reversal of 6 to lock 7 and of 14 to lock 13, and, finally, the clearing of signal 2. In the figure illustrated, the tower is placed on the drawbridge, although this is not necessary, as it may be located wherever desired.

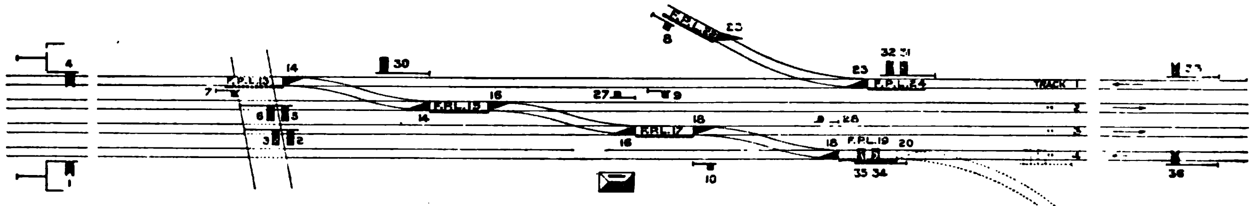


MACHINE

6 LEVERS FOR 6 SIGNALS
4 " " 4 DERAILS
4 " " 4 F.P.Ls
1 " " BRIDGE COUPLERS
1 " " RAIL LOCKS
1 STARTING LEVER 12
17 WORKING LEVERS
3 SPARE SPACES 4,5,17
20 LEVER FRAME

REVERSE	LOCKS	REVERSE	LOCKS
1	2	11	10
2	6-14-18	12	
3	8-16-19	13	11
4	SPARE SPACE	14	13
5	" "	15	11
6	7	16	15
7	11	17	SPARE SPACE
8	9	18	14-6
9	11	19	16-8
10	12	20	10

Figs. 636-637. Interlocking Plan and Locking Sheet, Double Track Drawbridge.

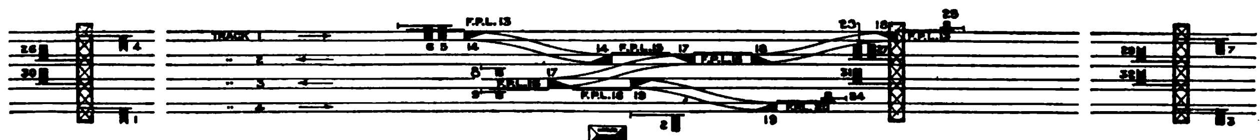


REVERSE	LOCKS	REVERSE	LOCKS	REVERSE	LOCKS	REVERSE	LOCKS
1	2	8	22-24-31	20	SPARE LEVER	29	SPARE LEVER
2	16-17-18-28	9	23-24-32	21	" "	30	14-13
3	16-17-18-19-34	10	18-19-35	22	23	31	24-22
4	5	11	SPARE SPACE	23		32	24-23
5	14-15-16-27	12	" "	24	23-25	33	32-36
6	14-15-16-17 28-34	13	14-14	25	SPARE SPACE	34	19-18-17
W	18-X 19	14		26	" "	W	16 X 15
7	13-30	15	14-14-16-16	27	16-15	W	16-14 X 13
W	14 X 32	16		W	14-X 13	35	19-18
W	14 X 15-27	17	16-16-18-18	28	18-17	36	35
W	14-16 X 17-28-34	18		W	16 X 15		
W	14-16-18 X 18	19	18-18	W	16-14 X 13		

MACHINE

18 LEVERS FOR 18 SIGNALS
4 " " 7 SWITCHES AND 1 DERAIL
6 " " 6 F.P.Ls.
29 WORKING LEVERS
3 SPARE LEVERS: 20,21,29
4 " SPACES: 11,12,25,26
36 LEVER FRAME

Figs. 638-639. Interlocking Plan and Locking Sheet, Crossovers and Turnouts on Four-Track Road.



MACHINE

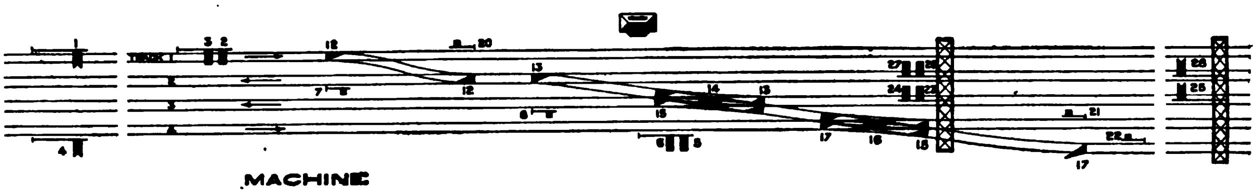
18 LEVERS FOR 18 SIGNALS
4 " " 8 SWITCHES
4 " " 8 F.P.Ls.
26 WORKING LEVERS
4 SPARE SPACES:10,11,21,22
2 " LEVERS:12,23.
32 LEVER FRAME

REVERSE	LOCKS	REVERSE	LOCKS	REVERSE	LOCKS	REVERSE	LOCKS
1	2-3	W	17 X 15-27	19	17	26	
2	19-20-24	W	17-18 X 13-25	20	19-19	27	18-15
3		10	SPARE SPACE	21	SPARE SPACE	W	17 X 14-13
4	5-7	11	" "	22	" "	W	17 X 16
5	13-14-18-25	12	SPARE LEVER	23	SPARE LEVER	28	18-15-17-14
6	13-14-15-25-27	13	14-14-18-18	24	17	29	28-24
7		14	17	W	19 X 16	30	
8	14-15-17-28	15	14-14-17-17-18-18	25	3	31	19-19-17
W	18 X 13-25	16	17-17-19-19	W	18 X 14	32	30-29
9	18-31	17		W	14 X 13		
W	17-19 X 20-24	18		W	18-17 X 16		

Figs. 640-641. Interlocking Plan and Locking Sheet, Crossovers on Four-Track Road.

Several peculiar situations are illustrated in Figs. 644-651. Reference to Figs. 644-645 shows that five dwarf signals, controlling movements from tracks 1 to 5, inclusive, are operated by one lever. The connections which operate these signals are so "selected" through switches 2, 3, 4 and 5, that it is possible to clear only one of the five signals at one time. (See Figs. 1482-1483). For instance, when the switches are set in the correct position for a movement from one of these tracks, then the reversal of lever 1 clears the signal governing movements from this track. The other four signals remain in the stop position. Fig. 644 shows the switches set in the correct position for a movement from track 5. If lever 1 is reversed the signal controlling movements from track 5 will be cleared. As the various signals operated by lever 1 govern movements over switches 2, 3, 4 and 5, in their normal and reversed positions, it is necessary for lever 1 reversed to lock these switches in both their normal and reversed positions. It is apparent, therefore, that if the switches were in the position shown, the reversal of lever 1 would clear the signal governing movements from track 5 and lock switch 5 in the normal position. It would also lock switches 2, 3 and 4 in whichever position they were when the lever was reversed.

There are two methods of arranging the locking for signal 6; both are shown on the locking sheet, one beneath the other. The first method requires that switches 4, 3 and 2 be locked through a series of specials, the second method that they be locked direct. It is evident that when the first method is used the switches over which the train is to move are locked when lever 6 is reversed. For instance, if a train is to make a movement from signal 6 to track 5, then switch 5 only would be locked with 6 reversed, thereby allowing the signalman to arrange switches 2, 3 and 4 in position for another movement. When the second method is employed the locking is simplified by elimination of the specials, but the action of reversing lever 6 locks all switches in whatever position they may then be; and consequently makes it impossible for the signalman to alter the position of any of the switches preparatory to setting up another route while lever 6 is reversed. The point in favor of the first method is that the operation of the machine is facilitated to a certain extent, while with the second the locking is considerably simplified.

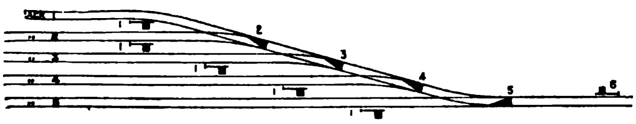


MACHINE

17 LEVERS FOR 17 SIGNALS
8 " " 7 SWITCHES, 2 M.P. FROGS AND 1 DERAIL
25 WORKING LEVERS
5 SPARE SPACES: 9, 10, 11, 18, 19.
28 LEVER FRAME

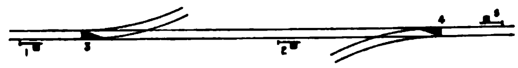
REVERSE	LOCKS	REVERSE	LOCKS	REVERSE	LOCKS	REVERSE	LOCKS
1	2	W	13 × 15-15	13		W	15-13 × 14·12-12
2	12-20	W	15-15 × 14·17-17-21-22	14	13-15	22	17·16-15
3	12·13-13-28-23	W	15-15-17 × 16	15		W	15 × 16-13-15
W	13 × 15 15	8	15·15-13-24	16	15-17	W	15-13 × 14·12-12
W	13-15 × 14·17-17·21·22	W	15 × 17-17·21·22	17		23	13·15·12-12
W	13-15-17 × 16	W	15-17-× 16	18	SPARE SPACE	24	13-15
4	5	9	SPARE SPACE	19	" "	25	24
5	17·15·21	10	" "	20	12	26	13-12
6	17·15-22	11	" "	21	15-15-17	27	13·12
7	12·15·15-27·23	12		W	15 × 13-15	28	27

Figs. 642-643. Interlocking Plan and Locking Sheet, Crossovers on Four-Track Road, Using Double Slip Switches with Movable Point Frogs.



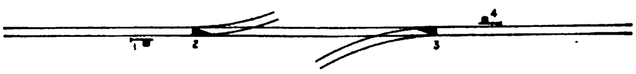
REVERSE	LOCKS
1	2·2·3·3·4·4·5·5·6
2	
3	
4	
5	
6	5·5
W	5 × 4·4
W	5·4 × 3·3
W	5·4·3 × 2·2
6	5·5·4·4·3·3·2·2

Figs. 644-645.



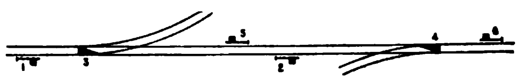
REVERSE	LOCKS
1	3·3
W	4 × 5
2	4·5
3	
4	
5	4·4
W	4 × 3

Figs. 646-647.



REVERSE	LOCKS
1	2·2
W	2 × 3·4
2	
3	
4	3·3
W	3 × 2

Figs. 648-649.

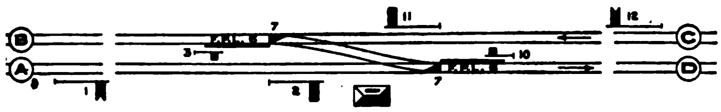


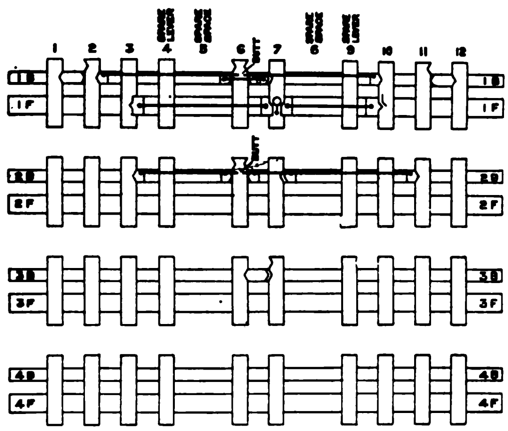
REVERSE	LOCKS
1	3 3-5
W	3-4 × 6
2	4-6
3	
4	
5	3
6	4-4

Figs. 650-651.

Figs. 644-651. Interlocking Plans and Locking Sheets Illustrating Special Conditions.

The layout and locking shown in Figs. 648-649 is illustrated that it may be compared with Figs. 646-651. The locking necessary to be explained in connection with these figures is that occurring between signals 1 and 5 (Figs. 646-647) and between signals 1 and 6 (Figs. 650-651). In Figs. 646-647 lever 1 should not lock 5 normal direct, as it is possible to make a movement from signal 1 to signal 2, or from signal 1 over switch 3, reversed at the same time that a train is moving from signal 5 over switch 4 reversed. Therefore, 1 reversed should lock 5 normal only when 4 is normal. Fig. 650 is similar, except that dwarf signal 5 is added. This signal makes it possible for a train to move from signal 6 to signal 5 while a movement is being made from signal 1 over 3 reversed, and necessitates the following special locking between levers 1 and 6: "1 reversed when 3 and 4 are normal locks 6 normal," it being apparent from the explanation given that if 3 and 4 are reversed, two movements could be made at the same time.

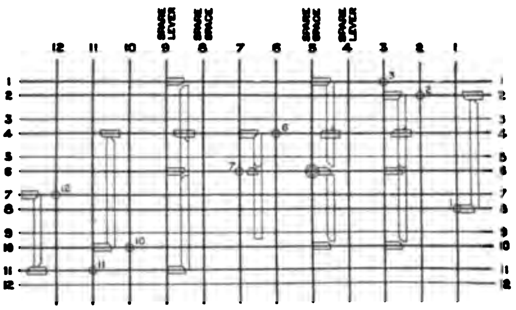




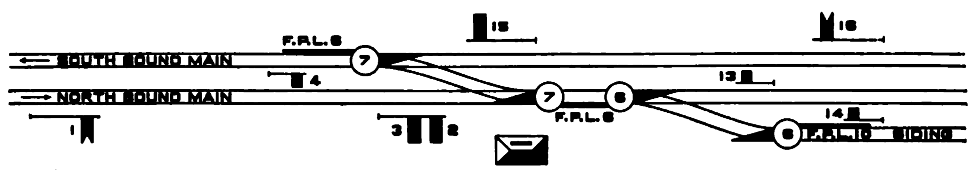
MACHINE

6 LEVERS FOR 6 SIGNALS
1 " " 2 SWITCHES
1 " " 2 F.P.Ls.
8 WORKING LEVERS
2 SPARE LEVERS 4, 9.
2 " SPACES 5, 8.
12 LEVER FRAME

REVERSE	LOCKS
1	2
2	7-6-10
3	6-11
W	7 X 10
4	SPARE LEVER
5	SPARE SPACE
6	7-7
7	•
8	SPARE SPACE
9	SPARE LEVER
10	6
11	7-6
12	11



Figs. 652-655. Interlocking Plan, Locking Sheet and Dog Charts; Crossover on Double Track.

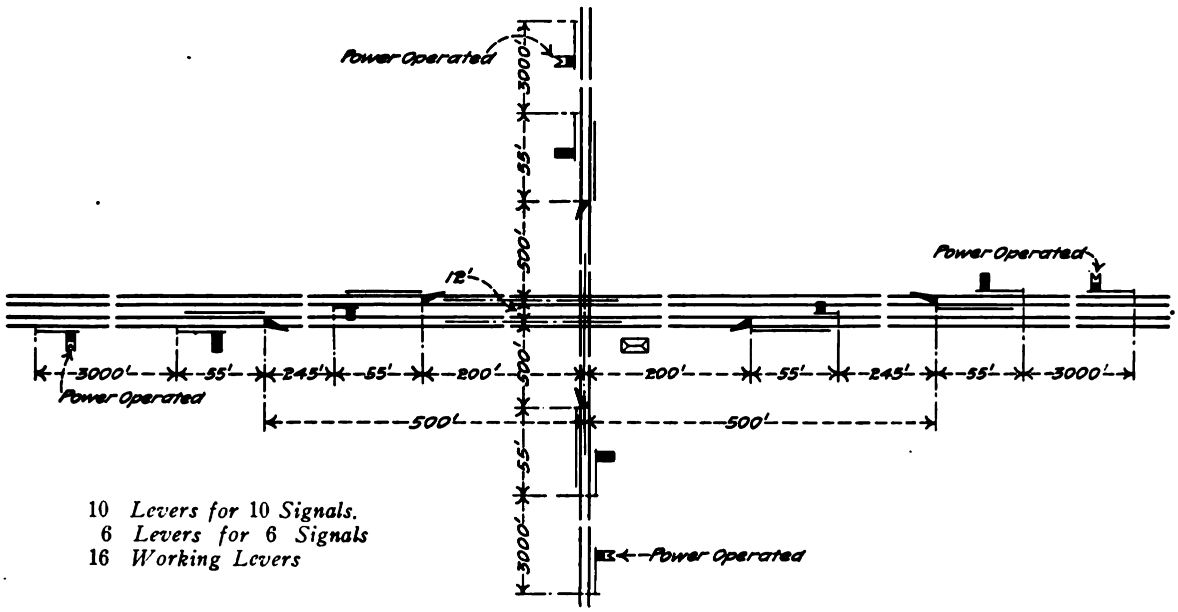


SPARE SPACES: 5,11,12.

NORTH BOUND	REVERSE LEVERS					
ON N.B. MAIN DIRECT	8	2	1			
FROM N.B. " TO SIDING	9	10	8	3		
ON S.B. " REVERSE	6	4				
FROM S.B. " TO N.B. MAIN	7	8	6	4		
" S.B. " " SIDING	9	10	7	5	6	4

SOUTH BOUND	REVERSE LEVERS					
ON S.B. MAIN DIRECT	6	15	16			
" N.B. " REVERSE	6	13				
FROM N.B. " TO S.B. MAIN	7	8	5	13		
" SIDING TO N.B. MAIN	8	5	10	14		
" SIDING " S.B. "	7	9	9	8	10	14

Fig. 656. Typical Tower Plan and Manipulation Chart.



10 *Levers for* 10 *Signals.*
6 *Levers for* 6 *Signals*
16 *Working Levers*

Fig. 657. Standard Interlocking Plan for Single Track Crossing Double Track at Grade. New York Central & Hudson River.

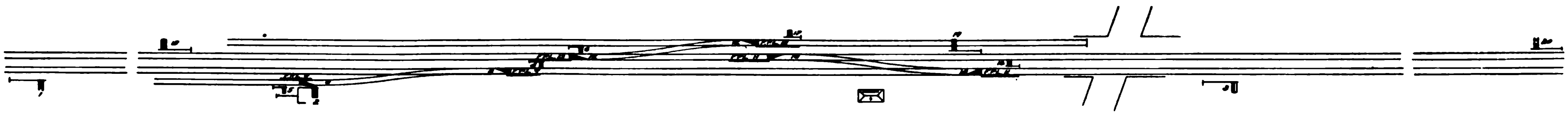


Fig. 658. Typical Interlocking Plan.

Lever.	Locking. Looks.
1	2 3
2	8 9 10 11 16
3	
4	13 11 (17 w 12) (16 w 10) -19
5	8 9 10 11 16
6	12 13 17
7	Spare.
8	10
9	8 8
10	12 13
11	10 10
12	
13	12 12
14	Spare.
15	Spare.
16	11 9
17	13
18	
19	10 11 12 13
20	19 18

Fig. 659. Locking Sheet for Fig. 658.

11 - Levers for signals.
3 - " " switches.
3 - " " locks.
17 - Working levers
3 - Spare " 7-14 & 15.
20 Lever Machine.

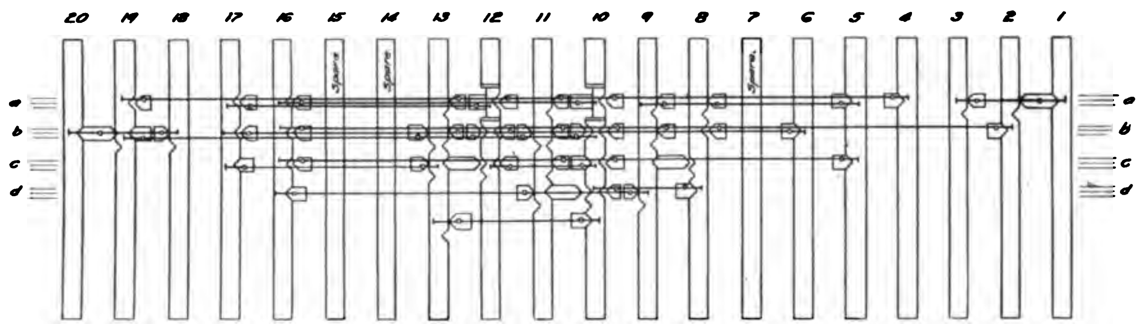
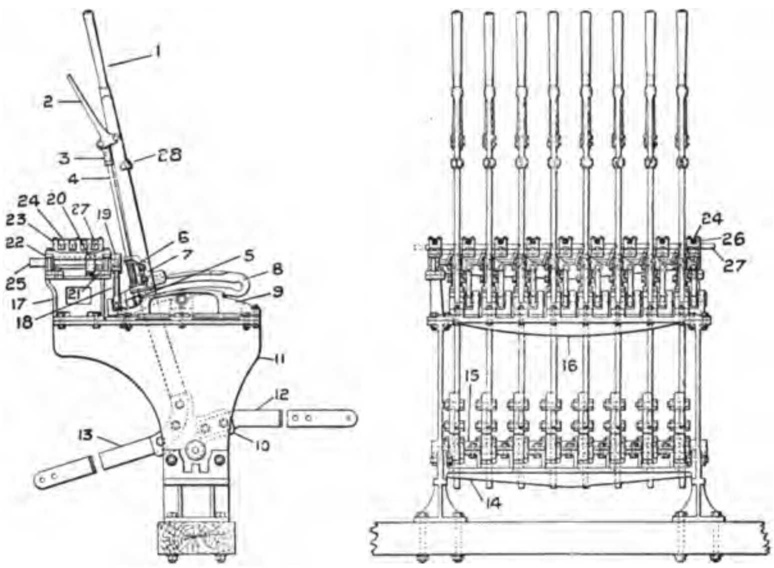


Fig. 660. Johnson Dog Chart for Figs. 658 and 659.

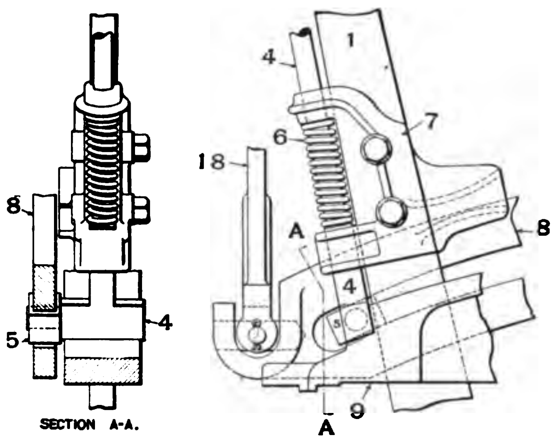
Names of Parts Saxby & Farmer Interlocking Machine; Figs. 661-665.

1 *Lever*
2 *Latch Handle*
3 *Latch Rod Thimble*
4 *Latch Rod*
5 *Rocker Die*
6 *Latch Spring*
7 *Latch Shoe*
8 *Rocker*
9 *Quadrant*
10 *Lever Shoe*
11 *Machine Leg*
12 *Back Tail Lever*
13 *Front Tail Lever (Part of 1)*
14 *Bottom Girder*
15 *Cap for Bottom Girder*
16 *Top Plate*
17 *Locking Bearing*
18 *Universal Link*
19 *Crank*
20 *Locking Bar Driver*
21 *Front Rail with Cap*
22 *Back Rail*
23 *Locking Bracket*
24 *Locking Bracket Cap*
25 *Rocking Shaft*
26 *Cross Locking*
27 *Longitudinal Locking Bar*
28 *Number Plate*

Numbers Refer to List of Names of Parts on Opposite Page.



*Figs. 661-662. Saxby & Farmer Interlocking Machine Arranged for Vertical Leadout.



Figs. 663-664. Saxby & Farmer Interlocking Machine—Details of Latch Rod Foot.

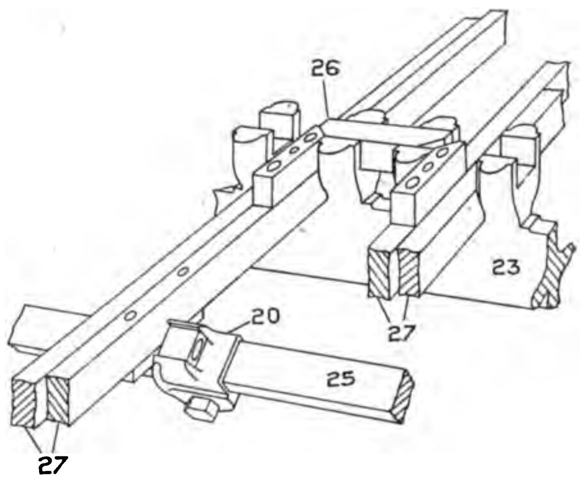


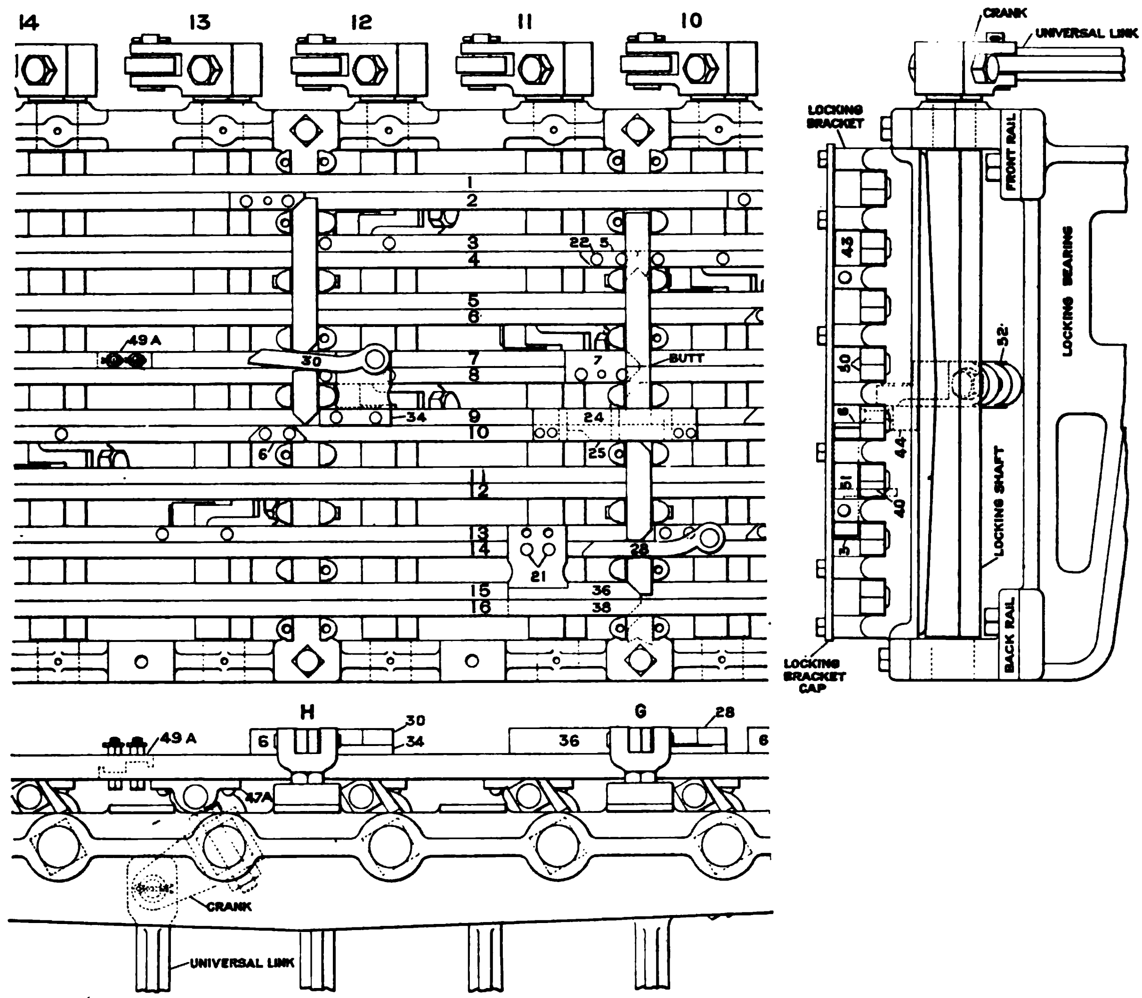
Fig. 665. Detail of Saxby & Farmer Locking.

THE SAXBY & FARMER INTERLOCKING MACHINE.

Figs. 661-664 and 717-721 illustrate a Saxby & Farmer interlocking machine assembled. Figs. 665-716 show various details of the machine. In the following description the numbers refer to Figs. 661-665. The latch handle 2 is pivoted on the lever 1 and is connected to the latch rod thimble 3. This, therefore, imparts motion, when operated, to the latch rod 4 and the rocker die 5. The latch rod thimble 3 is used to adjust the length of the latch rod 4. The rocker die 5 makes the connection between the latch rod and the rocker. The latch spring 6 is compressed when the latch handle 2 is raised. Upon releasing the latch handle, it is returned to its normal position by the spring 6, unless the lever is between the normal and reverse positions and, in consequence, the foot of the latch rod 4 (see detail Figs. 663-664) is held on top of the quadrant 9. The latch shoe 7 holds the spring 6 and the latch rod 4 in position. It also acts as a guide for the rocker. The rocker 8 is pivoted at the center of the quadrant 9. The quadrant also acts as a guide for the lever 1. To the lever is bolted the lever shoe 10 which, in its turn, is pivoted on a pin resting on the bottom girder 14. The back and front tail levers, 12 and 13, are used to connect the levers to the apparatus controlled. The bottom girder 14 is used to support the levers. Cap 15, for the bottom girder 14, holds in position the pin on which lever shoe 10 is pivoted. The top plate 16 carries the quadrants 9 which are bolted to it. Slots are cored in this plate to allow the levers to extend through it. The locking bearing 17 supports the front rails 21 and back rails 22, which, in turn, act as bearings for the locking shaft 25, and as supports for the locking brackets 23 (see detail Fig. 665). The universal link 18 connects the rocker 8 to the locking shaft crank 19; this crank is rigidly attached to the locking shaft 25. The locking bar driver 20 is fastened to the locking shaft 25. When operated it drives the longitudinal locking 27. The locking brackets 23 support the longitudinal locking 27 and the cross locking 26 (Fig. 665). The locking bracket caps 24 are used to hold the locking 26 and 27 in position (see detail Figs. 666-668). The locking shaft 25 makes the connection between the crank 19 and the locking bar driver 20. Fig. 665 shows a perspective view of cross locking 26 and longitudinal locking 27. A number plate 28 is placed on each lever, levers being numbered consecutively from left to right. The levers as shown in the machine are said to be in the normal position. When in the opposite position, they are said to be reversed. The locking shafts 25, when operated, turn in bearings on the rails 21 and 22.

To convey a clear idea of the operation of the locking in an interlocking machine, it will be necessary to give an explanation of preliminary latch locking. A lever in a machine is held in position until the latch rod foot (Figs. 663-664) has been raised above the quadrant, by the raising of the latch handle. Through the rocker and locking shaft, this movement of the latch handle imparts one-half of the full throw to the longitudinal locking. This, in turn, actuates the cross locking and locks all conflicting levers that before this action were unlocked. It keeps locked all levers that should remain locked, until the lever is moved to its opposite position and the latch rod foot has, by the lowering of the latch handle, engaged with the stop on the quadrant. This holds the lever in position and completes the throw of the longitudinal locking. When a signalman desires to operate a lever, he raises the latch handle. This imparts an upward motion to the latch rod and rocker die and gives the rocker one-half of its full throw. The rocker transmits an upward

Numbers Refer to List of Names of Parts Below.



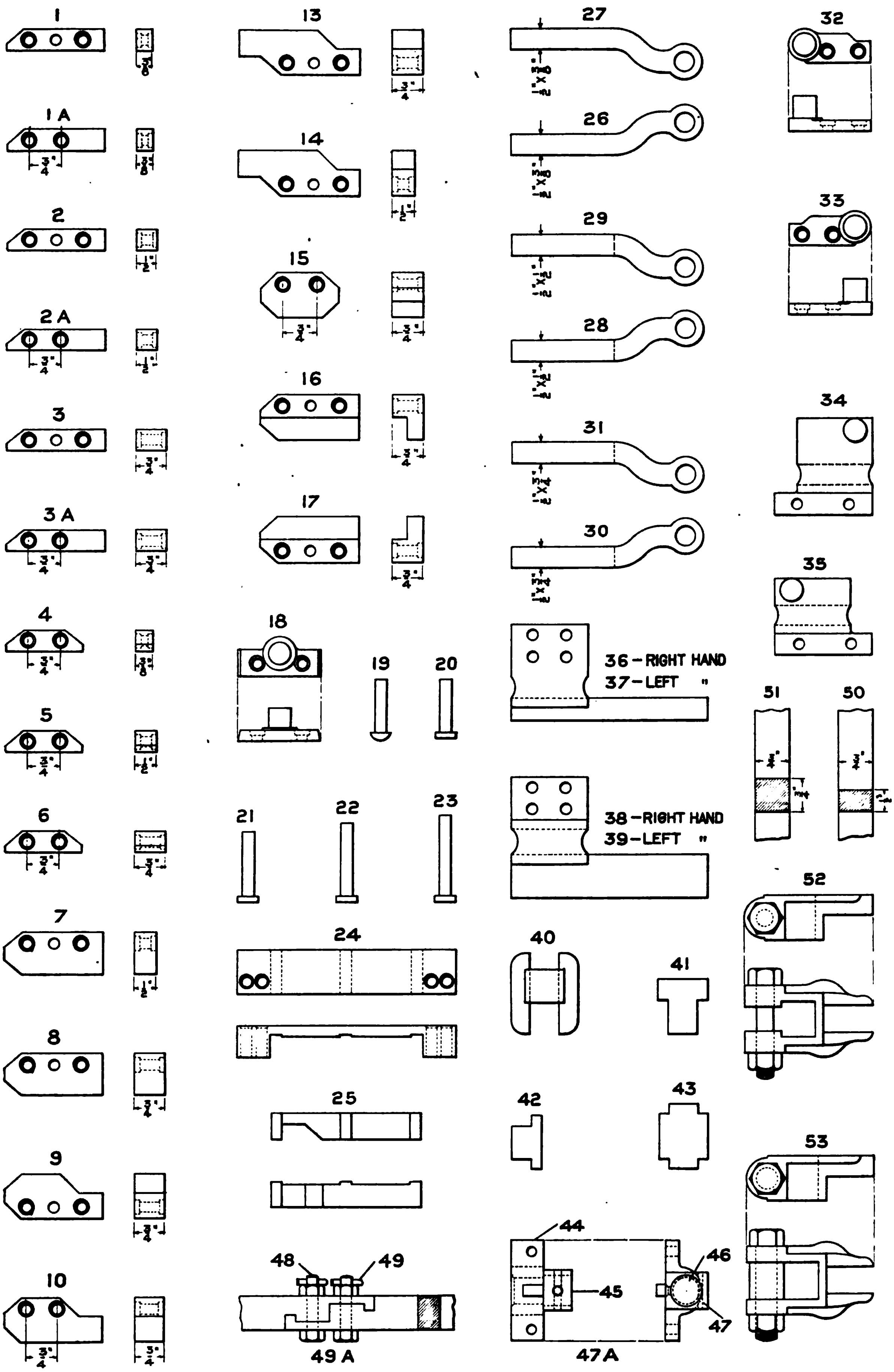
Figs. 666-668. Saxby & Farmer Locking.

NOTE.—In Figs. 666 and 668 the brackets are illustrated without caps in order to show the locking more clearly.

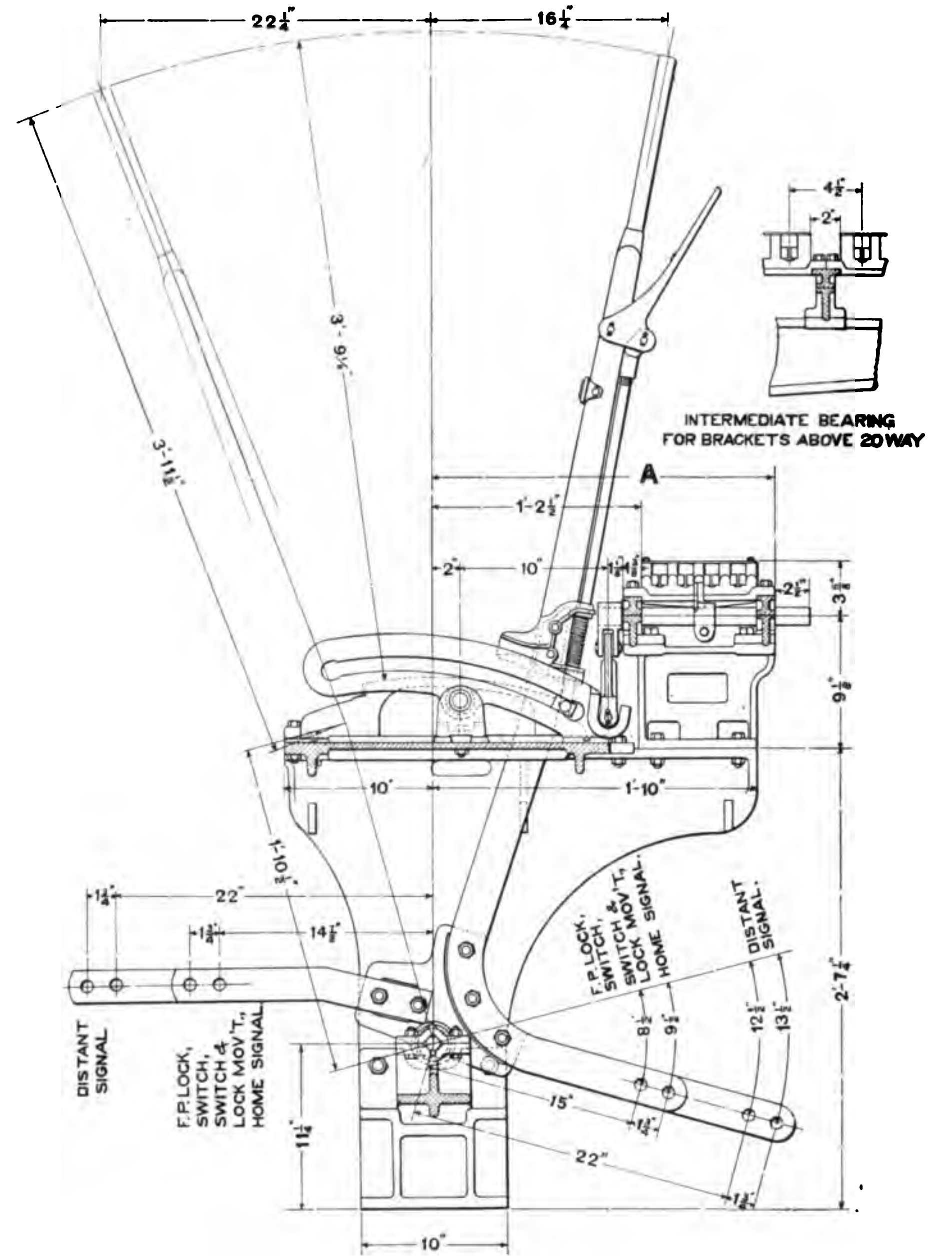
Names of Parts of Saxby & Farmer Locking Details; Figs. 666-716.

1 *No. 1 Locking Dog, 3/8" x 1/2"*
1A *No. 1A Locking Dog, 3/8" x 1/2"*
2 *No. 2 Locking Dog, 1/2" x 1/2"*
2A *No. 2A Locking Dog, 1/2" x 1/2"*
3 *No. 3 Locking Dog, 3/4" x 1/2"*
3A *No. 3A Locking Dog, 3/4" x 1/2"*
4 *No. 4 Locking Dog, 3/8" x 1/2"*
5 *No. 5 Locking Dog, 1/2" x 1/2"*
6 *No. 6 Locking Dog, 3/4" x 1/2"*
7 *No. 7 Locking Dog, 1/2" x 1"*
8 *No. 8 Locking Dog, 3/4" x 1"*
9 *No. 9 Locking Dog, 3/4" x 1"*
10 *No. 10 Locking Dog, 3/4" x 1"*
13 *No. 13 Locking Dog, 3/4" x 1"*
14 *No. 14 Locking Dog, 1/2" x 1"*
15 *No. 15 Locking Dog, 3/4" x 1"*
16 *No. 16 Locking Dog, 3/4" x 1"*
17 *No. 17 Locking Dog, 3/4" x 1"*
18 *Right or Left Hand Trunnion*
19 *Rivet, 1/4" x 15/16", for Fixing* **44** *to Locking Bars*
20 *Rivet, 1/4" x 11/16", for Trunnions*
21 *Rivet, 1/4" x 17/32", for 3/8" Locking Dogs*
22 *Rivet, 1/4" x 1 11/32", for 1/2" Locking Dogs*
23 *Rivet, 1/4" x 1 19/32", for 3/4" Locking Dogs*
24 *Special Locking Dog Guide*
25 *Special Locking Dog*
26 *Left Hand Swing Dog, 3/8" Thick*
27 *Right Hand Swing Dog, 3/8" Thick*
28 *Left Hand Swing Dog, 1/2" Thick*
29 *Right Hand Swing Dog, 1/2" Thick*
30 *Left Hand Swing Dog, 3/4" Thick*
31 *Right Hand Swing Dog, 3/4" Thick*
32 *Left Hand Trunnion*
33 *Right Hand Trunnion*
34 *Left Hand Special Reach Trunnion*
35 *Right Hand Special Reach Trunnion*
36 *Right Hand Special Reach Dog, 1/2" Wide*
37 *Left Hand Special Reach Dog, 1/2" Wide*
38 *Right Hand Special Reach Dog, 1" Wide*
39 *Left Hand Special Reach Dog, 1" Wide*
40 *Filling Piece for Locking Bar*
41 *Filling Piece for Cross Locks.*
42 *Filling Piece for Cross Locks*
43 *Filling Piece for Cross Locks*
44 *Locking Bar Driver*
45 *Locking Bar Driving Block*
46 *Locking Bar Driving Stud*
47 *Steel Pin, 1/8" x 7/8", for Fastening* **45** *to* **46**
47A *Locking Bar Driver, Block and Stud Comp.*
48 *Hex. Bolt and Nut, 1/4" x 1 9/16", for Making Splice in Locking Bars*
49 *Cotter Pin, 3/32" x 5/8", for* **48**
49A *Locking Bar, Splice Comp.*
50 *Locking Bar, 1/2" x 3/4", C. D. Steel, Used for Longitudinal Bars*
51 *Locking Bar, 3/4" x 3/4", C. D. Steel, Used for Cross Locks*
52 *Locking Bar Driver*
53 *Locking Bar Driver*

Numbers Refer to List of Names of Parts on Opposite Page.



*Figs. 669-716. Saxby & Farmer Locking Details.



*Figs. 717-718. Outline of the Saxby & Farmer Interlocking Machine; Arranged for Vertical Leadout.

motion to the universal link. This, through the medium of the crank, turns the locking shaft. Turning the locking shaft gives, through the locking bar driver, one-half of the throw to the longitudinal locking and this, in turn, gives the full throw to the cross-locking. When the lever is fully moved to the opposite position, the latch spring forces the foot of the latch rod into engagement with the stop on the quadrant, thereby imparting the other half of the throw to the rocker and, consequently, to the longitudinal locking. It can readily be understood that throwing the lever does not transmit any motion to the locking and that it is impossible to release a lever which should not be thrown because the latch cannot be raised. As very little power can be applied to the latch handle, the strain on the locking is small compared with that in machines where the locking is actuated by the movement of the lever.

Figs. 615, 617, 630 and 653 show dog charts for Saxby & Farmer interlocking machines. The long horizontal lines represent the locking bars and are numbered in the order in which they are placed in the machine, commencing with the one next to the levers. A small circle drawn on this line shows by which lever the bar is worked and where the connection is made. Locking brackets are numbered to correspond with the levers. Cross locking is stamped with the number of the bracket in which it is to be placed. It is also stamped at each end with the number of the locking bar under that end. This is done in order that the bars and cross locking may be easily replaced in the machine if they have been removed for any reason. The cross locking is represented as being placed close to the dog by which the locking is performed; the clearance necessary to allow it to be moved is left next to the other dog. This is done in order to facilitate reading of the dog chart by showing which lever does the locking. When one lever locks two or more levers the cross locking is notched for as many dogs as there are levers to be locked. (See Fig. 666, bracket G.) Reversal of the locking lever forces the cross locking over against the dogs of the other levers and locks them. If one of the other levers has been reversed the cross locking will strike against the dog of that lever and prevent the lever from being reversed.

Special locking is shown at 30, bracket H, in Fig. 666. This is used when one lever is to lock a second lever only when a third lever is in a given position. It consists of a dog of special form pivoted on the locking bar so that it can be moved sidewise by the two pieces of cross locking between the edges of which it projects. It also moves lengthwise with the longitudinal bar to which it is pivoted. In the position shown the two pieces of cross locking act as one, as the clearance space between them is taken up. If the special swing dog is withdrawn it will allow either of the two pieces of cross locking to be moved and the first and second lever reversed regardless of each other, and if both are reversed the lever which carries the swing dog is locked.

SAXBY & FARMER INTERLOCKING MACHINE

HORIZONTAL LEADOUT.

Machines such as those shown in Figs. 719-720 are designed for use on the ground floor of buildings and on the deck level of drawbridges. They are almost identical in construction with those already described.

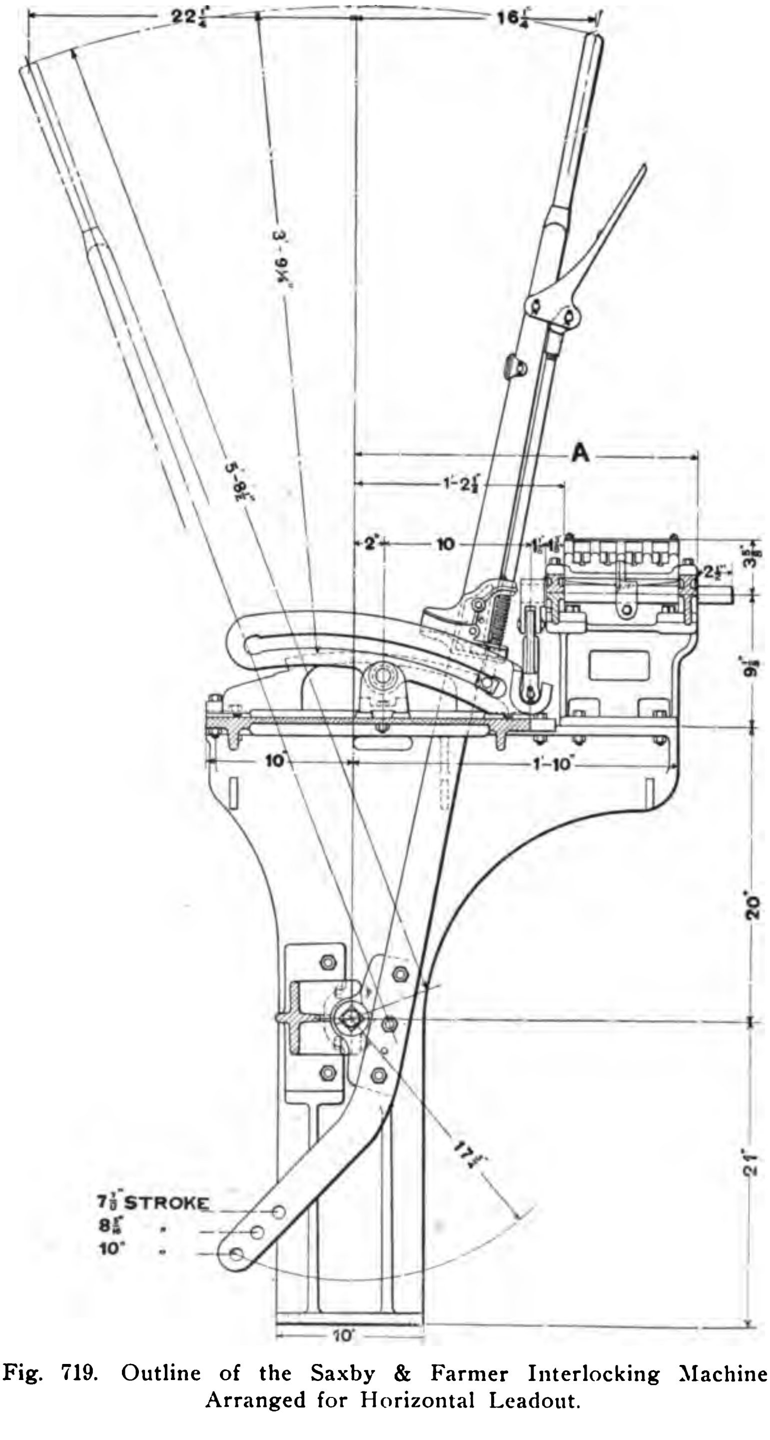


*Fig. 719. Outline of the Saxby & Farmer Interlocking Machine; Arranged for Horizontal Leadout.

STANDARD INTERLOCKING MACHINE

VERTICAL LOCKING.

As many of the parts of the Standard machine (Figs. 722-772) are similar to those of the Saxby & Farmer (Figs. 661-721), such parts only as are different will be explained. The latch block and roller (see detail Figs. 724-725) do the same work as the foot of the latch rod and the rocker die in the Saxby & Farmer machine. The latch block 6 is also used to adjust the length of the latch rod. The segment 7 is of slightly different design, but performs the same function as the quadrant used with the Saxby & Farmer machine. The rocker 8 has a lug cast on one end which extends through and above the segment, upon which the signalman may press with his foot, and thus with less effort raise the latch handle 2. The rocker guide 9 which is riveted to the lever, acts as a guide for the rocker. The back and front girders 10 and 11, respectively, support the segments. The back girder also acts as a stop for the levers. The tappet connecting link 17 connects the rocker 8 to the tappet 19. The tappet jaw 18 is rigidly screwed to the tappet 19, which directly actuates the back and front locking, 24 and 25 (also see detail Figs. 726-728). The locking plate 21 supports the back and front locking 24 and 25 and guides the tappets 19. The back locking 24 is placed in the same plane as the

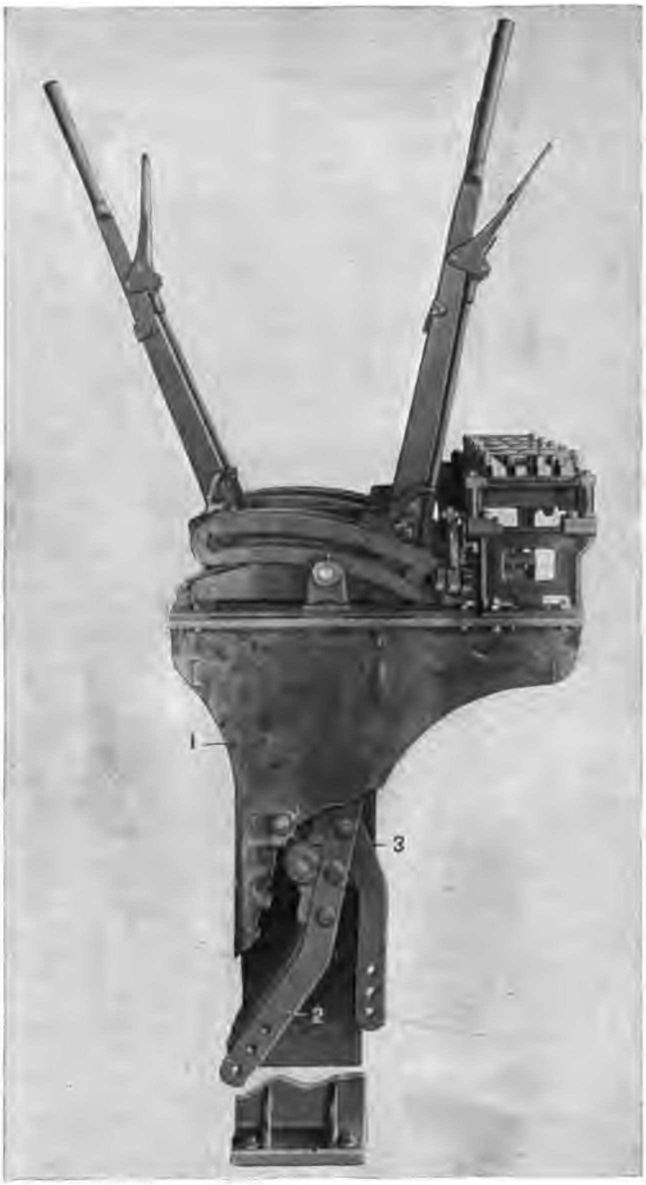


*Fig. 720. The Saxby & Farmer Machine, Horizontal Leadout.

tappets between which this locking is accomplished. The front locking 25 is placed in front of the back locking. The front locking guides 22 are screwed to the locking plate 21, to support and guide the front locking. The locking plate strip 23 is placed in front of the front locking to hold it in place.

The operation of the standard machine, which accomplishes practically the same results as that of the Saxby & Farmer, is as follows: When the signalman desires to operate a lever, he first raises the latch handle, which, in its turn, raises the latch rod and latch block and compresses the latch spring (Figs. 724-725). This releases the lever and at the same time gives the rocker one-half of its throw. The rocker transmits its throw through the connecting link to the tappet and locking. When the lever has been moved to the opposite position, the latch spring forces the latch block into engagement with the stop on the segment, and it thus imparts the other half of the throw to the rocker, and, consequently, to the tappet and locking. The locking plates, which are attached to and supported by the machine legs, are constructed with four separate spaces for locking. The upper space is known as space 1, the next as space 2, and so on. Two tiers of locking may be placed in each space, the back tier being called the back locking and the front tier the front locking (see Sections A-A and B-B, Figs. 726-728). 4-F and 4-B (Section B-B) designate "The 4th space, front locking," and "The 4th space, back locking," respectively. This section also shows the relative positions of the front and back locking dogs and locking bars. It is possible to place three bars, side by side, in the space provided for the back locking bars, and five bars, side by side, in the space provided for the front locking bars (see Section A-A, showing two back locking bars and three front locking bars).

The mechanical construction of the locking is that of a bar or tappet locked by a dog moving at right angles to it and fitting in a notch cut in the edge of the tappet. For instance, the two adjacent levers 6 and 7, Fig. 771 (space 2B) are interlocked by the dog 13, which is made longer than the space between the two tappets. Thus one tappet will be free to move only when the dog slides into the notch cut in the other. Unless the notch in the second bar is in a position to allow the dog to be forced over, the tappet is locked and the lever cannot be moved. When the two levers to be interlocked are not next to each other, the dogs are connected together by a small locking bar 42 (Figs. 729-770), as shown between tappets 12 and 14 (space 1 B), Figs. 726 and 771.

The dogs consist of tapered pieces of steel (1-6, 13-16, 20, and 25-29, Figs. 729-770). In the case of front locking small lugs, known as tappet pieces (9A-12) are fastened to the tappets and the dogs strike against these as they would against the side of the notch in back locking. Special locking is employed as in the Saxby & Farmer machine. In this case the special consists of a swing dog 8 pivoted to the tappet. In other types of machine of this class, the special is usually a block sliding in a notch in the tappet.

If necessary a locking plate may also be placed on the opposite side of the machine legs beneath the front tail lever (16, Fig. 722), and tappets connected to the eye in the front end of the rocker.

A dog chart for a standard machine is shown in Figs. 613 and 618. For the sake of clearness the front and back locking for a given space is grouped as shown. Where front locking is shown (Fig. 618) the tappet pieces fastened to the outside of the tappet are shown only by lines representing their active faces.

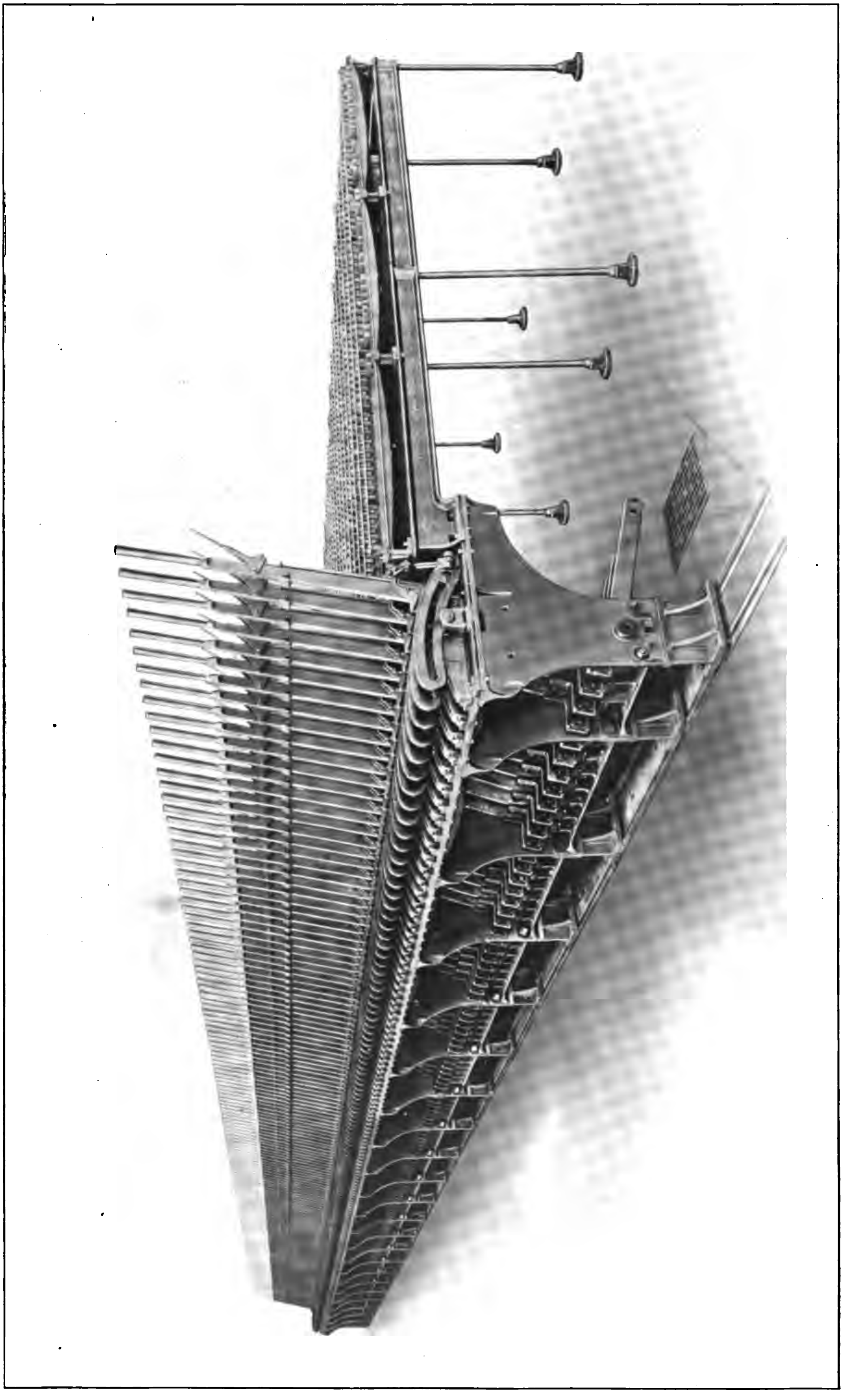
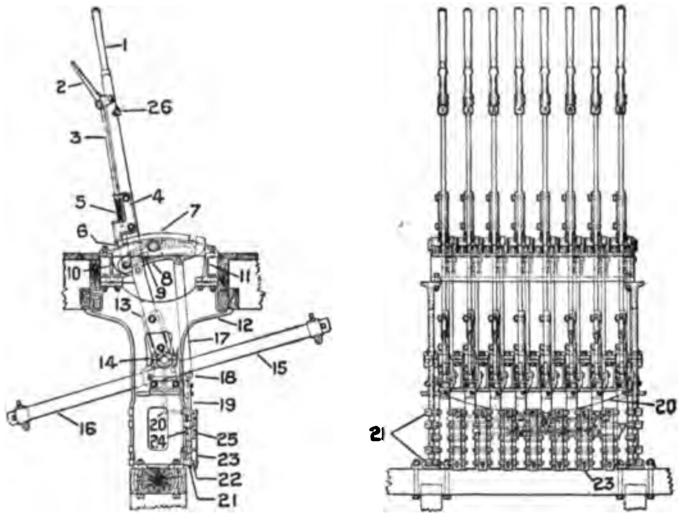


*Fig. 721. One-hundred-and-seventy-two-Lever Saxby & Farmer Interlocking Machine Assembled in Factory.

Numbers Refer to List of Names of Parts Below.

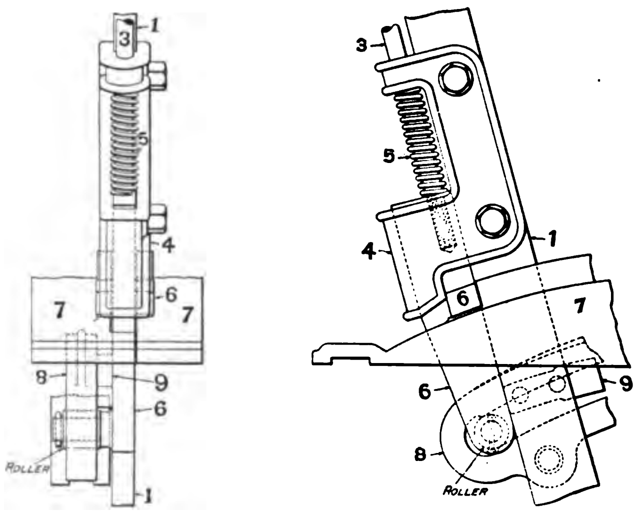


*Figs. 722-723. Standard Interlocking Machine.

Names of Parts Standard Interlocking Machine; Figs. 722-728.

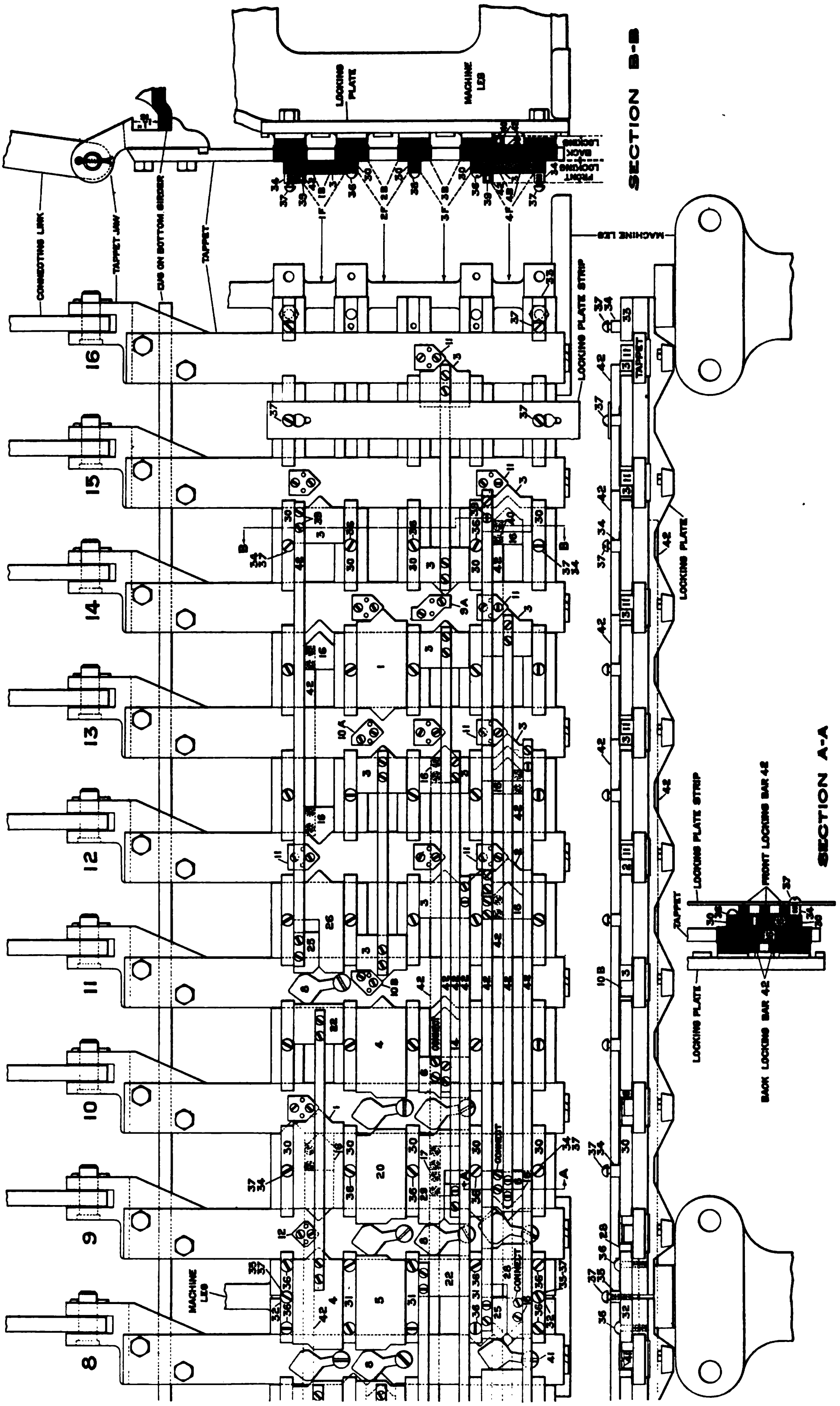
1 *Lever*
2 *Latch Handle*
3 *Latch Rod*
4 *Latch Shoe*
5 *Latch Spring*
6 *Latch Block*
7 *Segment*
8 *Rocker*
9 *Rocker Guide*
10 *Back Girder*
11 *Front Girder*
12 *Machine Leg*
13 *Lever Shoe*
14 *Cap*
15 *Back Tail Lever*
16 *Front Tail Lever*
17 *Tappet Connecting Link*
18 *Tappet Jaw*
19 *Tappet*
20 *Top Plate*
21 *Locking Plate*
22 *Front Locking Guide*
23 *Locking Plate Strip*
24 *Back Locking*
25 *Front Locking*
26 *Number Plate*

Numbers Refer to List of Names of Parts Above.



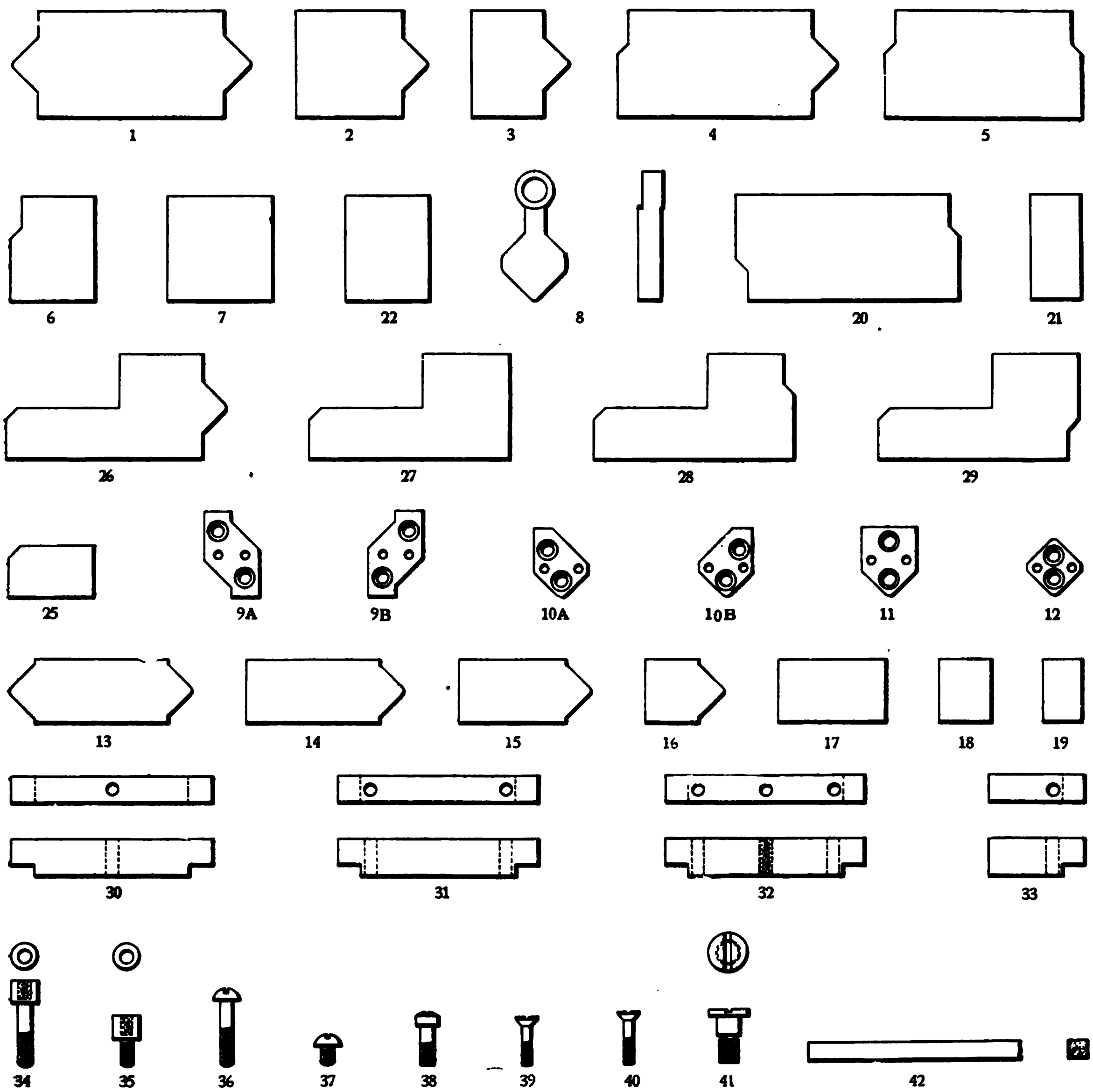
Figs. 724-725. Standard Interlocking Machine; Details of Latch Block.

Numbers Refer to List of Names of Parts on Page with Fig. 772.



*Figs. 726-728. Standard Locking in Place on Locking Plate; Representing a Portion of Figs. 772-773.

Numbers Refer to List of Names of Parts on Opposite Page.



*Figs. 729-770. Standard Locking Details.

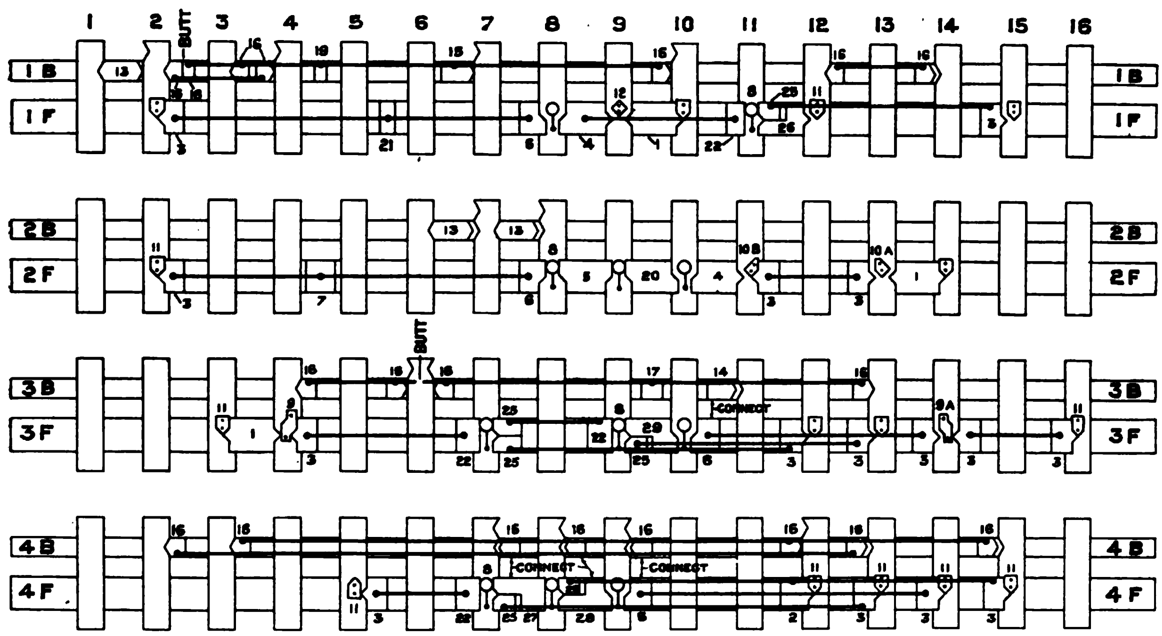
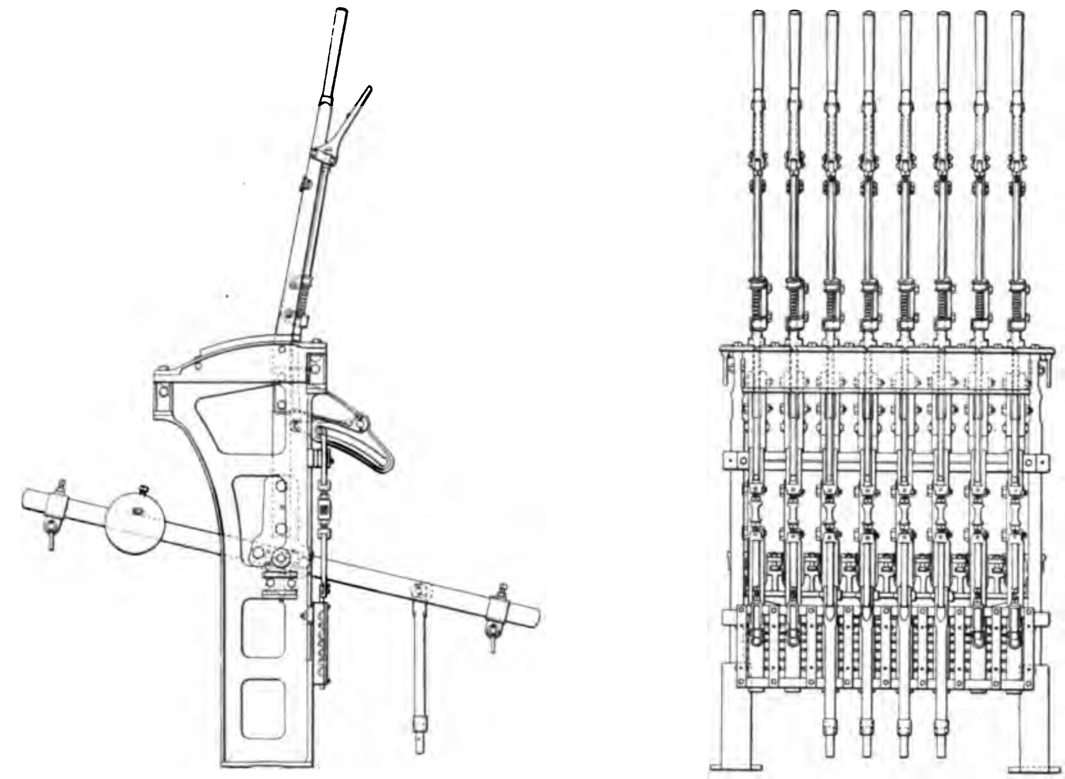


*Fig. 771. Diagram of Standard Locking Details Assembled. A Portion of This Locking is Shown in Figs. 726-728.

*Fig. 772. Standard Interlocking Machine.

Names of Parts of Standard Locking Details; Figs. 726-771.

1 *No.* 1 *Front Locking Dog*
2 *No.* 2 *Front Locking Dog*
3 *No.* 3 *Front Locking Dog*
4 *No.* 4 *Front Locking Dog*
5 *No.* 5 *Front Locking Door*
6 *No.* 6 *Front Locking Dog*
7 *No.* 7 *Front Coupling Dog*
8 *No.* 8 *Special Swing Dog*
9A *No.* 9*A Tappet Piece*
9B *No.* 9*B Tappet Piece*
10A *No.* 10*A Tappet Piece*
10B *No.* 10*B Tappet Piece*
11 *No.* 11 *Tappet Piece*
12 *No.* 12 *Tappet Piece*
13 *No.* 13 *Back Locking Dog*
14 *No.* 14 *Back Locking Dog*
15 *No.* 15 *Back Locking Dog*
16 *No.* 16 *Back Locking Dog*
17 *No.* 17 *Back Coupling Dog*
18 *No.* 18 *Back Carrier Dog*
19 *No.* 19 *Back Carrier Dog*
20 *No.* 20 *Front Locking Dog*
21 *No.* 21 *Front Carrier Dog*
22 *No.* 22 *Front Locking Dog*
25 *No.* 25 *Front Locking Dog*
26 *No.* 26 *Front Locking Dog*
27 *No.* 27 *Front Locking Dog*
28 *No.* 28 *Front Locking Dog*
29 *No.* 29 *Front Locking Dog*
30 *No.* 1 *Front Locking Guide*
31 *No.* 2 *Front Locking Guide*
32 *No.* 3 *Front Locking Guide*
33 *No.* 4 *Front Locking Guide*
34 *Special Stud for Use with* **30**
35 *Special Stud for Use with* **32**
36 14/24 x 1⅛" *Round Head Machine Screw for Fastening Front Locking Guides* **30, 31, 32** *and* **33** *to Locking Plate*
37 14/24 x ⅝" *Machine Screw for Use with* **34** *and* **35**
38 14/24 x ¾" *Filister Head Machine Screw for Fastening Tappet Pieces to Tappet*
39 10/32 x 13/16" *Flat Head Machine Screw Used for Fastening Front Lock Dogs, Couplers and Carriers to Locking Bar* **42**
40 10/32 x 15/16" *Flat Head Machine Screw Used for Fastening Back Locking Dogs, Couplers and Carriers to Locking Bar* **42**
41 *Stud for Fastening and Pivoting Special Swing Dog* **8** *on Tappet*
42 *Locking Bar*



*Figs. 773-774. Johnson Interlocking Machine.

Numbers Refer to List of Names of Parts Below.

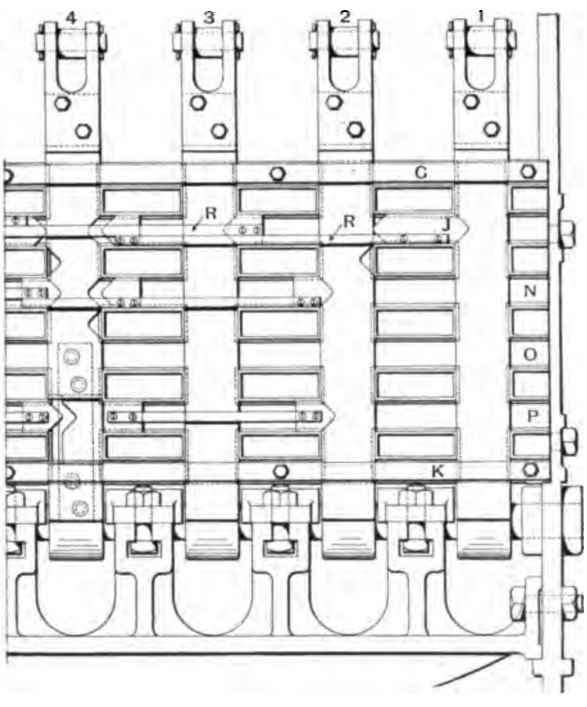
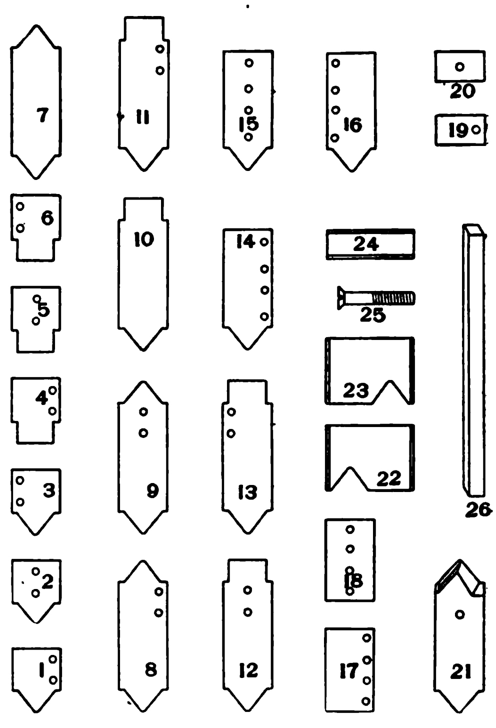


*Fig. 775. Johnson Locking.



*Figs. 776-801. Johnson Locking Details.

Names of Parts of Johnson Locking Details; Figs. 776-801.

1 *Locking Dog*
2 *Locking Dog*
3 *Locking Dog*
4 *Locking Dog*
5 *Locking Dog*
6 *Locking Dog*
7 *Locking Dog*
8 *Locking Dog*
9 *Locking Dog*
10 *Locking Dog*
11 *Locking Dog*
12 *Locking Dog*
13 *Locking Dog*
14 *Locking Dog*
15 *Locking Dog*
16 *Locking Dog*
17 *Locking Dog*
18 *Locking Dog*
19 *Locking Dog*
20 *Locking Dog*
21 *Locking Dog*
22 *Special Locking Dog*
23 *Locking Dog*
24 *Spacing Strip*
25 10/32" x 7/8" *Special Steel Screw for Locking Dogs*
26 3/8" x 3/8" *Steel Locking Bar*

THE JOHNSON INTERLOCKING MACHINE

This machine (Figs. 773-802) differs from others of the vertical locking type in that the tappet moves upward when the lever is being reversed, instead of downward; also, the rocker is attached to a bracket which is rigidly connected to the lever and, therefore, moves with it, the connection between the rocker and tappet having only a vertical motion. The locking dogs, etc., used in this machine are similar to those used in the National machine (Figs. 806-873), and to those used in the back locking of the Standard machine (Figs. 729-770). As may be seen, preliminary latch locking is a feature of this machine.

*Fig. 802. The Johnson Interlocking Machine.

THE NATIONAL INTERLOCKING MACHINE

This machine (Figs. 803-873) is somewhat similar in design and operation to the Standard; the lever, the latch handle and its connections, the rocker and the link connecting it to the tappet vary only slightly in design. Locking plates are often provided on both sides of the machine legs and operated as in the Standard machine. The type of locking used is similar to that used in the Johnson machine and to the back locking in the Standard, although a greater variéty of dogs is necessary to secure the same results.

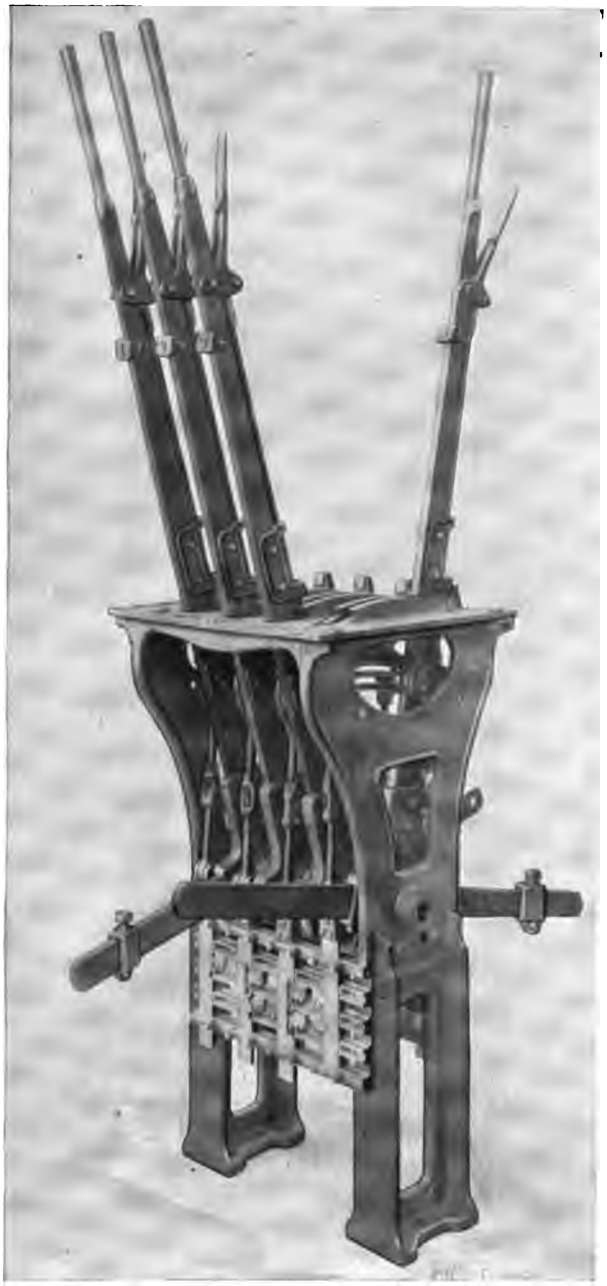


*Fig. 803. The National Interlocking Machine.

Letters Refer to List of Names of Parts Below.

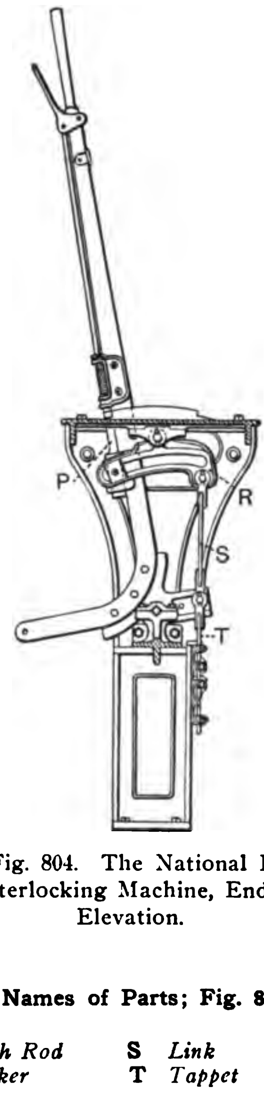


*Fig. 804. The National Interlocking Machine, End Elevation.

Names of Parts; Fig. 804.

P	*Latch Rod*	S	*Link*
R	*Rocker*	T	*Tappet*

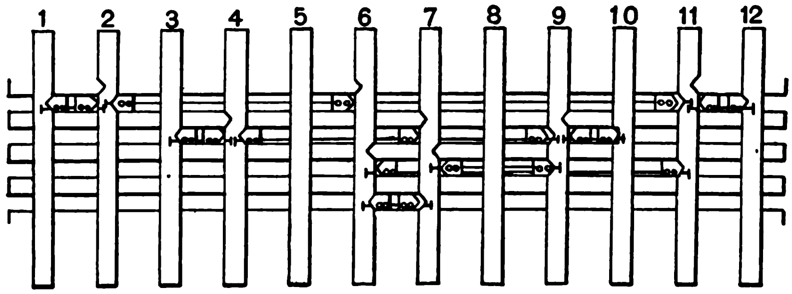
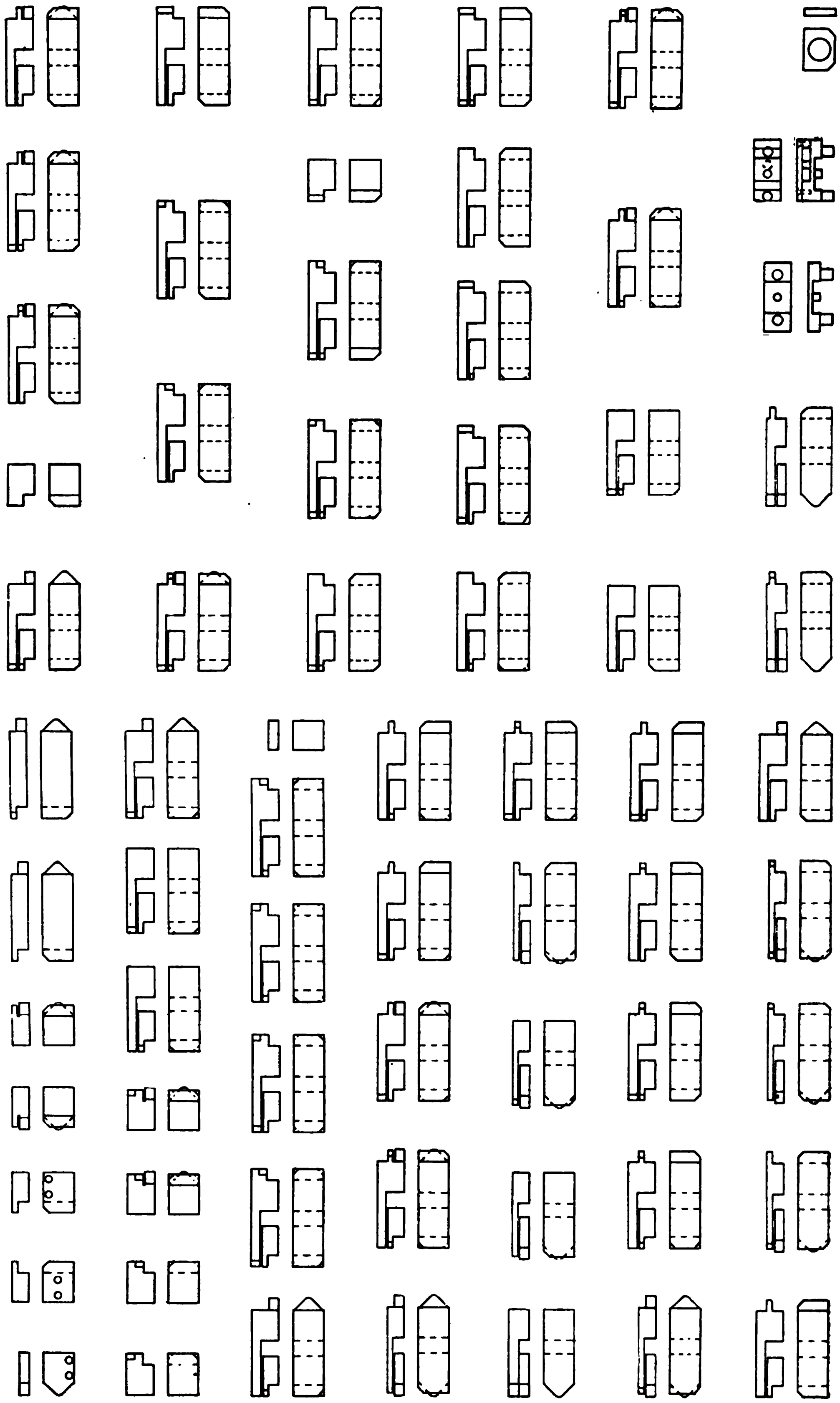


Fig. 805. Typical Diagram of Locking for a National Machine.



*Figs. 806-873. National Locking Details.

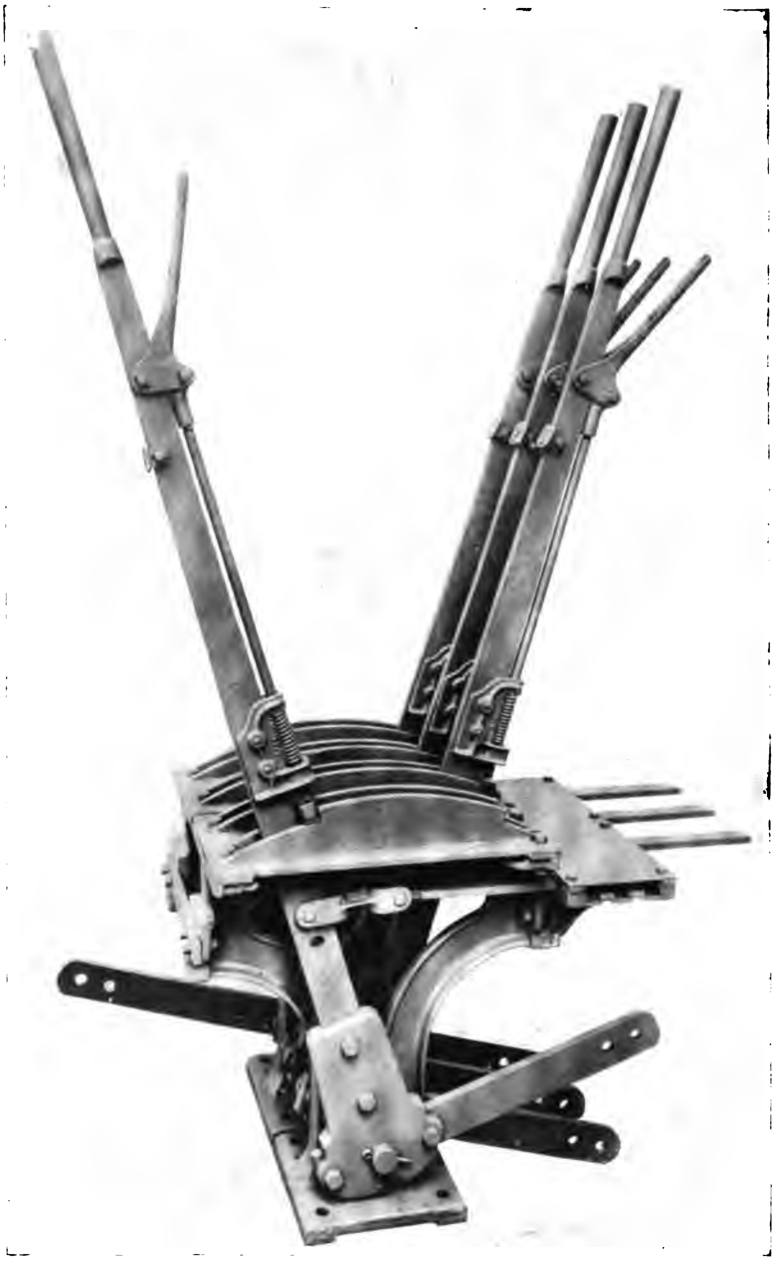


Fig. 874. The Stevens Interlocking Machine.

STEVENS INTERLOCKING MACHINE

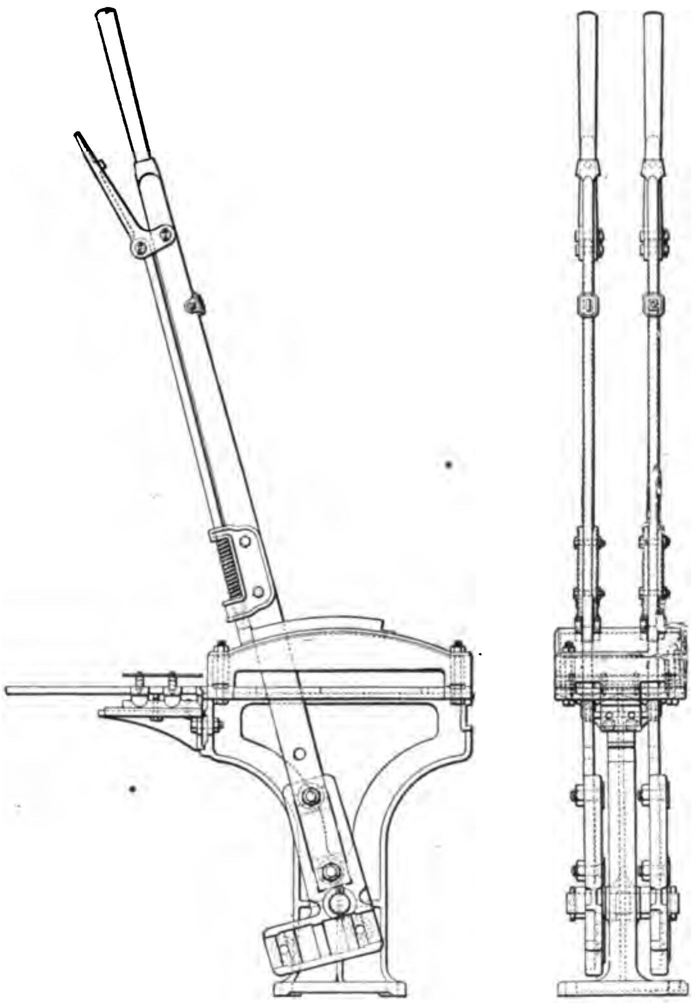
The Stevens interlocking machine is shown in Fig. 874. It is designed to work and control a small number of switches and signals at points where the space for installing a machine is limited or where it is found advantageous to control a number of yard switches from a central point. It can be operated on the ground level with horizontal connections, or can be set on a platform and be vertically connected. This type of machine is made without preliminary latch locking.

STYLE "C" INTERLOCKING MACHINE

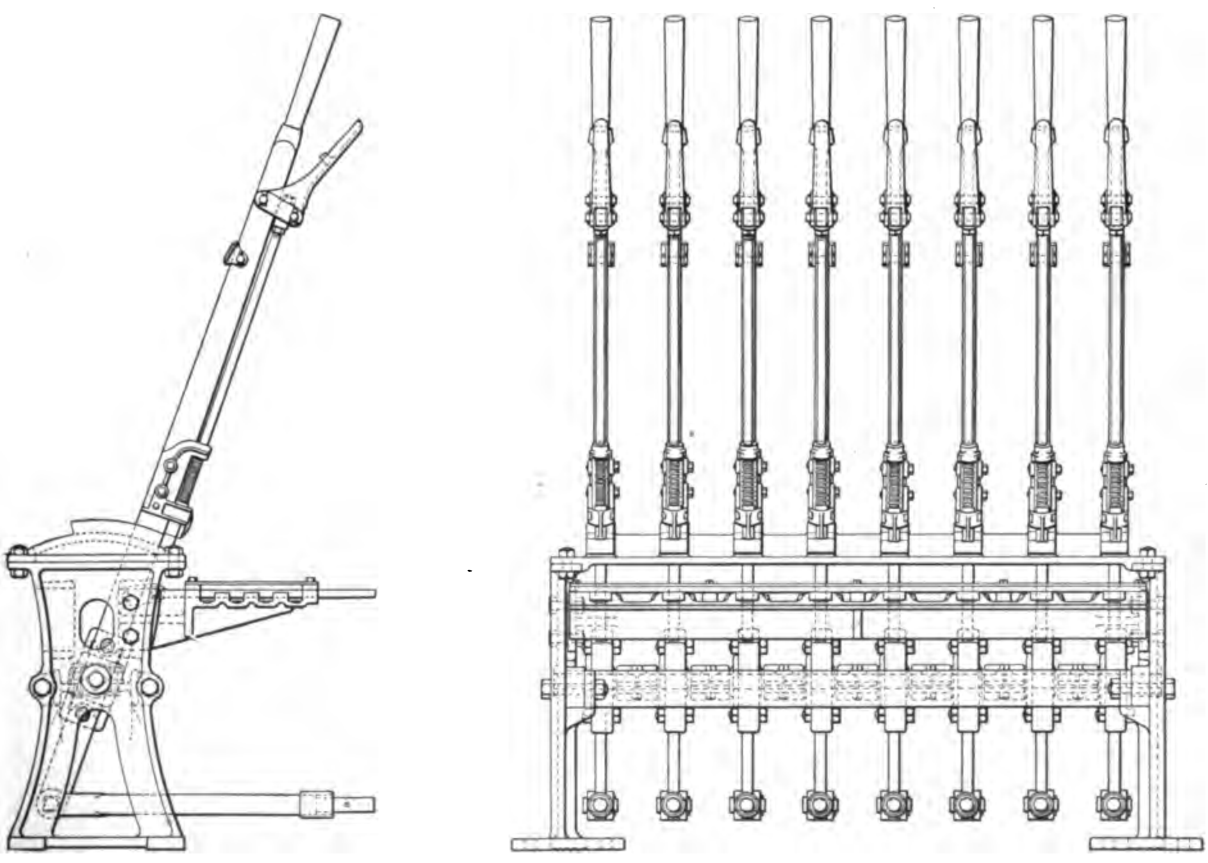
The Style "C" interlocking machine, shown in Figs. 875-876, is similar in design to the Stevens and is intended for use under the same conditions.

DWARF INTERLOCKING MACHINE

Figs. 877-881 illustrate what is known as the Dwarf Interlocking Machine. Dwarf machines are designed for use at outlying switches and on elevated railroads, where they may be set on ties or on low platforms at track level. They can also be used instead of the Stevens or Style "C" machine, except where a vertical leadout is necessary. The dwarf machines are made without preliminary locking.

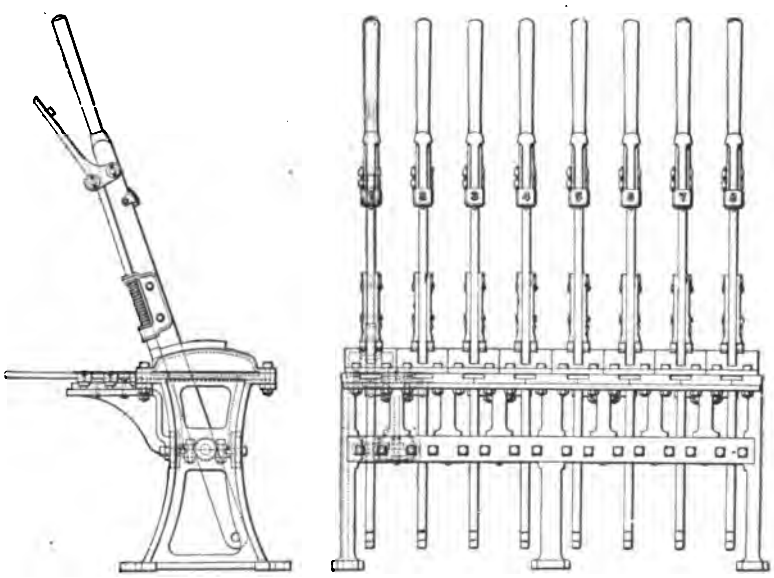


*Figs. 875-876. Style "C" Interlocking Machine.



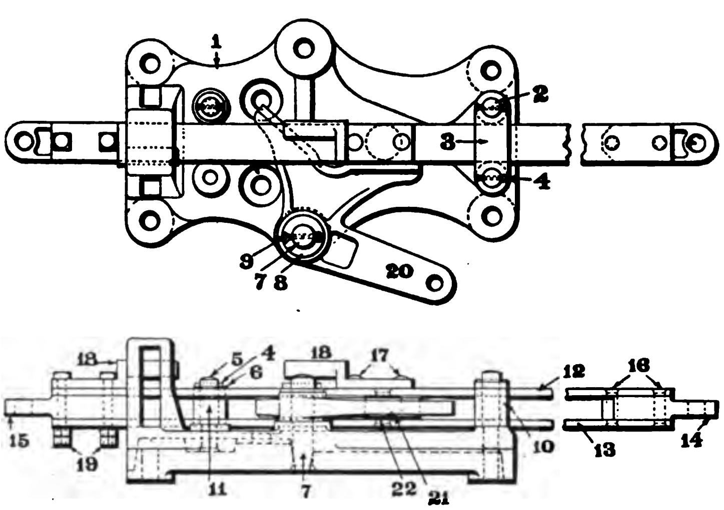
Figs. 877-878. Dwarf Interlocking Machine. The Union Switch & Signal Company.

Fig. 879. Dwarf Interlocking Machine. The Union Switch & Signal Company.

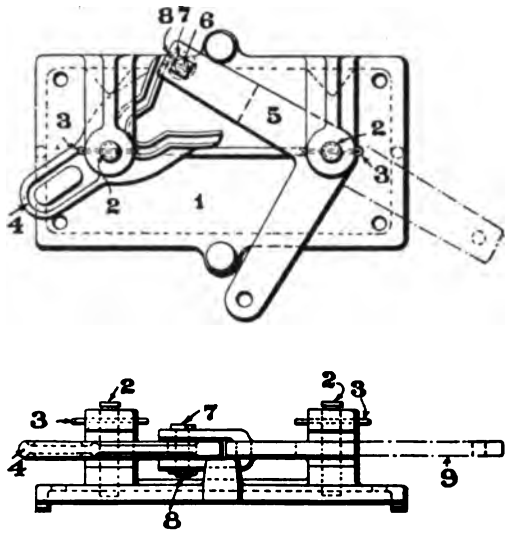


*Figs. 880-881. Style "D" Dwarf Interlocking Machine.

Numbers Refer to Lists of Names of Parts Below.



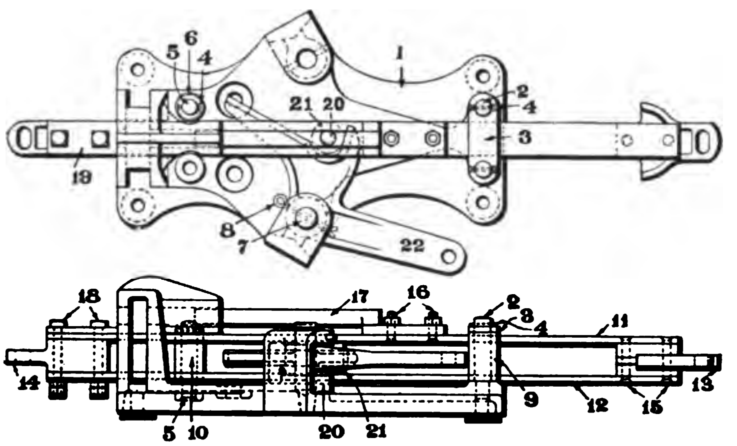
*Figs. 882-883. Switch and Lock Movement for Switch.



*Figs. 884-885.—Johnson Type Switch and Lock Movement.

Names of Parts of Switch and Lock Movement; Figs. 882-883.

1 *Base*
2 1" x 5" *Stud*
3 *Cap for Guide Rollers*
4 ¼" x 1¾" *Cotter*
5 1" x 4" *Stud*
6 *Washer*
7 1¼" x 5" *Stud*
8 *Washer*
9 *Cotter*
10 *Guide Roller*
11 *Guide Roller*
12 *Upper Slide Bar*
13 *Lower Slide Bar*
14 *Lug for Slide Bar*
15 *Lug for Slide Bar*
16 *Rivet*
17 *Rivet*
18 ½" x 4¼" *Bolt*
19 *Bolt*
20 *Escapement Crank*
21 *Operating Roller*
22 1" x 3" *Stud*



*Figs. 886-887. Switch and Lock Movement for Derails, Locking One Way Only.

Names of Parts for Johnson Type Switch and Lock Movement; Figs. 884-885.

1 *Base*
2 *Pin*
3 *Cotter*
4 *Escapement Crank*
5 *Crank*
6 *Pin*
7 *Operating Roller*
8 *Cotter*
9 *Special T Crank*

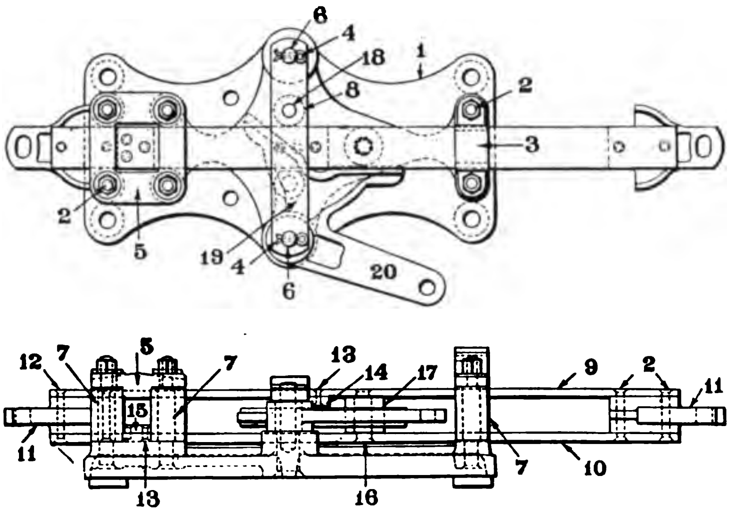
Names of Parts of Derail Switch and Lock Movement; Figs. 886-887.

1 *Base*
2 *Stud*
3 *Cap for Guide Rollers*
4 *Cotter*
5 *Stud*
6 *Washer*
7 *Pin*
8 *Cotter*
9 *Guide Roller*
10 *Guide Roller*
11 *Upper Slide Bar*
12 *Lower Slide Bar*
13 *Slide Bar Lug*
14 *Slide Bar Lug*
15 ½" x 3" *Rivet*
16 *C. S. H. Bolt*
17 *Locking Plunger*
18 ½" x 4¼" *Bolt*
19 *Slide Bar Stop*
20 ¾" x 3" *Pin*
21 *Operating Roller*
22 *Escapement Crank*

GENERAL DETAILS OF MECHANICAL INTERLOCKING CONSTRUCTION

Next to the interlocking machine (Figs. 661-881) the most important part of an interlocking plant is the mechanism by which the switches are operated. The simplest arrangement that could be used would be a direct connection from the lever to the head rod of the switch. This would throw the switch but, as there is considerable spring in the connection, it would give no assurance that the switch had entirely completed its movement. For this reason some form of locking is necessary. This is accomplished in two ways; by facing point locks and by switch and lock movements.

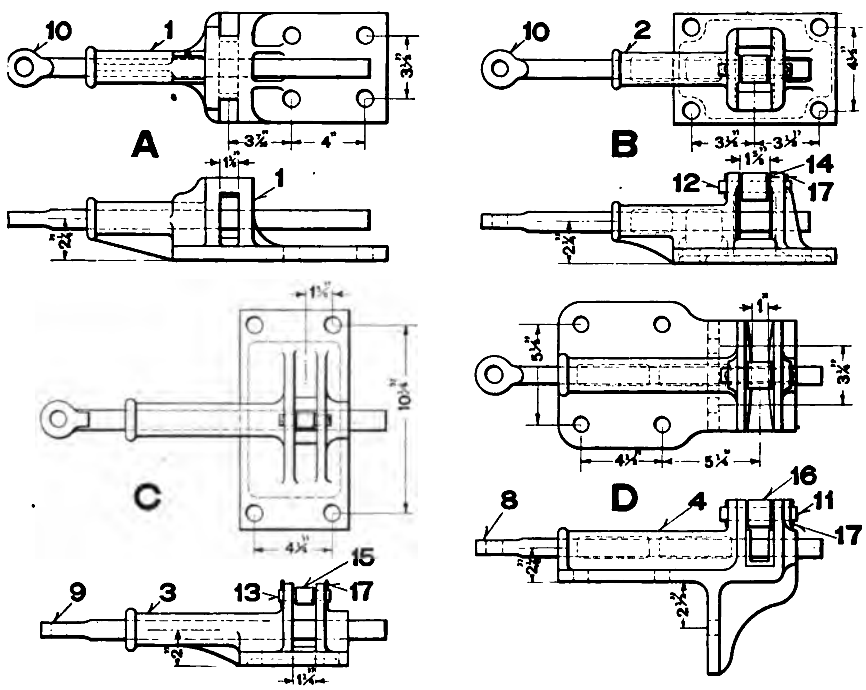
A facing point lock (Figs. 890-915, 919) consists of a plunger casting, a plunger, and a lock rod. The lock rod is attached to the movable part of the switch and passes through a slot in the plunger casting. The plunger is operated by a separate lever (interlocked with the switch lever) and moves through the plunger casting at right angles to the lock rod. When the switch is either fully



*Figs. 888-889. Switch and Lock Movement Using Notched Lock Rod.

Names of Parts of Switch and Lock Movement; Figs. 888-889.

1 *Base*
2 *Stud*
3 *Cap for Guide Rollers*
4 *Cotter*
5 *Yoke for Guide Rollers and Lock Rod*
6 *Stud*
7 *Guide Roller*
8 *Center Guide Roller*
9 *Upper Slide Bar*
10 *Lower Slide Bar*
11 *Lug for Slide Bar*
12 *Rivet*
13 *Rivet*
14 *Upper Locking Dog*
15 *Lower Locking Dog*
16 *Pin*
17 *Operating Roller*
18 *Pin*
19 *Cap for Crank and Center Roller*
20 *Escapement Crank*



*Figs. 890-897. Plunger Locks.

Names of Parts Plunger Locks; Figs. 898-909.

A *Single Plunger Locking Stand*
B *Double Plunger Locking Stand for Adjustable Lock Rod*
C *Left Hand Single Plunger Locking Slide*
D *Single Plunger Locking Stand, Wide Base, Roller Bearing*
E *Double Plunger Locking Stand. Wide Base, for Adjustable Lock Rod, Roller Bearing*
F *Duplex Facing Point Lock*
1 *Plunger Casting for A*
2 *Plunger Casting for B*
3 *Plunger Casting for C*
4 *Plunger Casting for D*
5 *Plunger Casting for E*
6 *Plunger Casting for F*
7 *Plunger*
8 *Right Hand Plunger for F*
9 *Left Hand Plunger for F*
10 *Yoke Rod*
11 *Roller Pin*
12 *Roller Pin*
13 *Roller for D*
14 *Roller for E*
15 *Cotter*

Names of Parts Plunger-Locks; Figs. 890-897.

A *Single Plunger Lock*
B *Double Plunger Lock, Roller Bearing*
C *Single Plunger Lock, Roller Bearing, Wide Base*
D *Left Hand Single Plunger Lock, Roller Bearing*

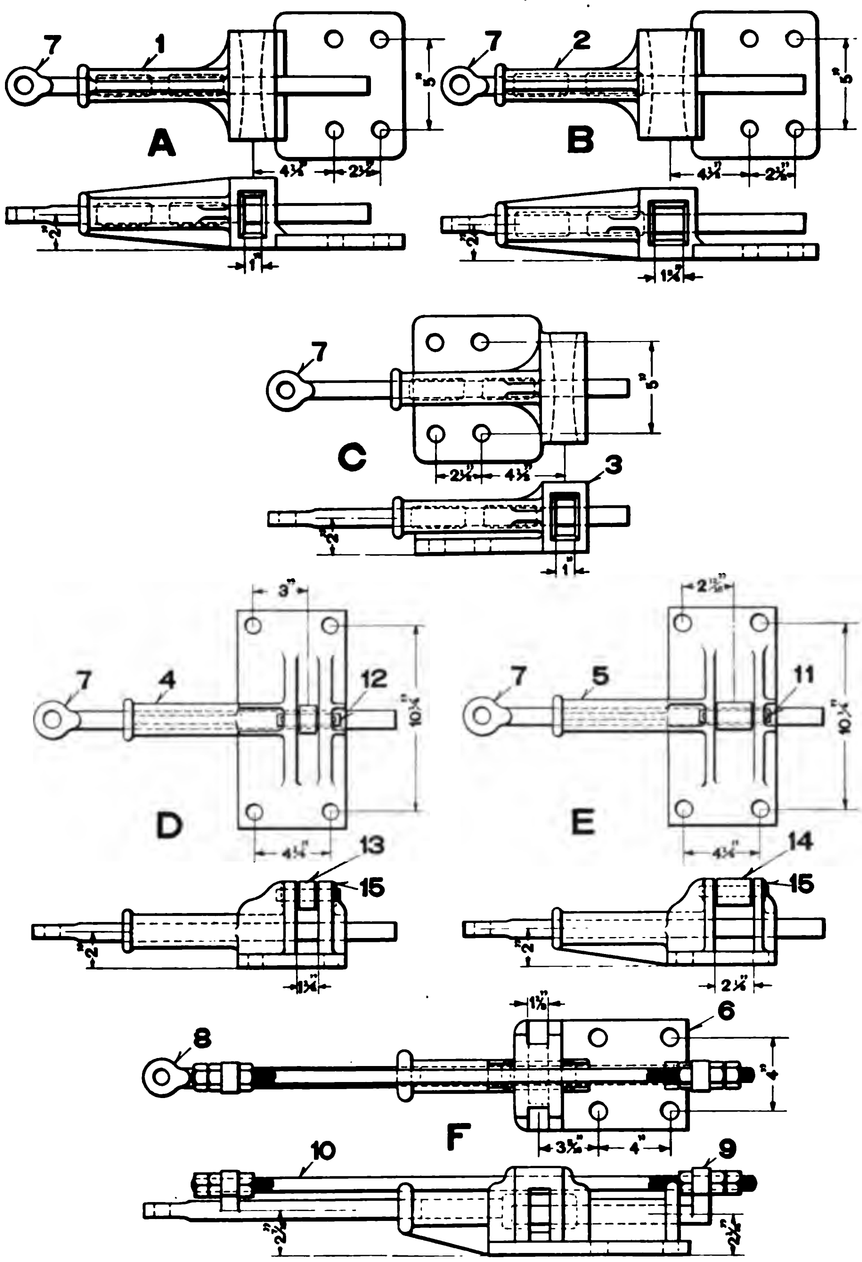
1 *Plunger Casting for A*
2 *Plunger Casting for B*
3 *Plunger Casting for C*
4 *Plunger Casting for D*
8 *Plunger for D*
9 *Plunger for C*
10 *Plunger for A and B*

11 *Roller Pin for D*
12 *Roller Pin for B*
13 *Roller Pin for C*
14 *Roller for B*
15 *Roller for C*
16 *Roller for D*
17 *Cotter*

normal or fully reversed, one or the other of two holes drilled in the lock rod is in line with the hole in the plunger casting through which the plunger moves, and when the lever which operates the plunger (known as the lock lever, see Figs. 612-656) is reversed, the plunger passes through the lock rod, thereby holding the switch firmly in place. Facing point locks are applied in two ways known as inside connected (Figs. 910-911) and outside connected (Figs. 912-915, 919). In the former, the plunger casting is mounted on the head block between the rails and the head or bridle rod is used as lock rod. In the latter the plunger casting is mounted outside the rails and a separate rod (see Figs. 936-939 and 941-949) is attached to the head rod, or may be made part of it. Outside connected facing point locks are more extensively used because they are not liable to injury from dragging brake rigging, etc.

The use of facing point locks necessitates an additional lever in the machine and a separate line of connections. To save the cost of these, switch and lock movements (Figs. 882-889) are sometimes employed. A switch and lock movement consists essentially of a frame on which are mounted an operating bar, escapement crank, and guides for the operating bar and lock rod. To the operating bar are attached lugs or plungers for locking the switch by entering holes or notches in the lock rod, and a lug for driving the escapement crank, which actuates the throw rod and moves the switch. Normally one lug or plunger is engaged with the lock rod, holding the switch locked. When the operating rod is moved the first portion of its stroke withdraws the plunger or lug and unlocks the switch, the second portion actuates the escapement crank and throws the switch and the last portion inserts the other plunger or lug locking the switch. These plungers or lugs may be of different shapes or placed in such relation to each other that they cannot both enter the same notch or hole in the lock rod.

Numbers and Letters Refer to List of Names of Parts on Opposite Page.



*Figs. 898-909. Plunger Locks.

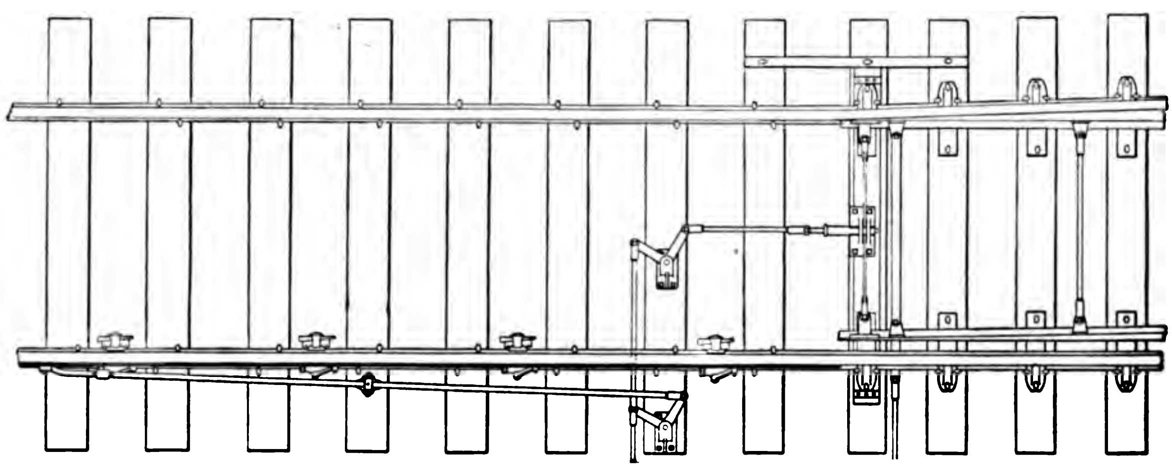


Fig. 910. Inside Connected Facing Point Lock and Switch Fittings. Detector Bar Ahead of Points.

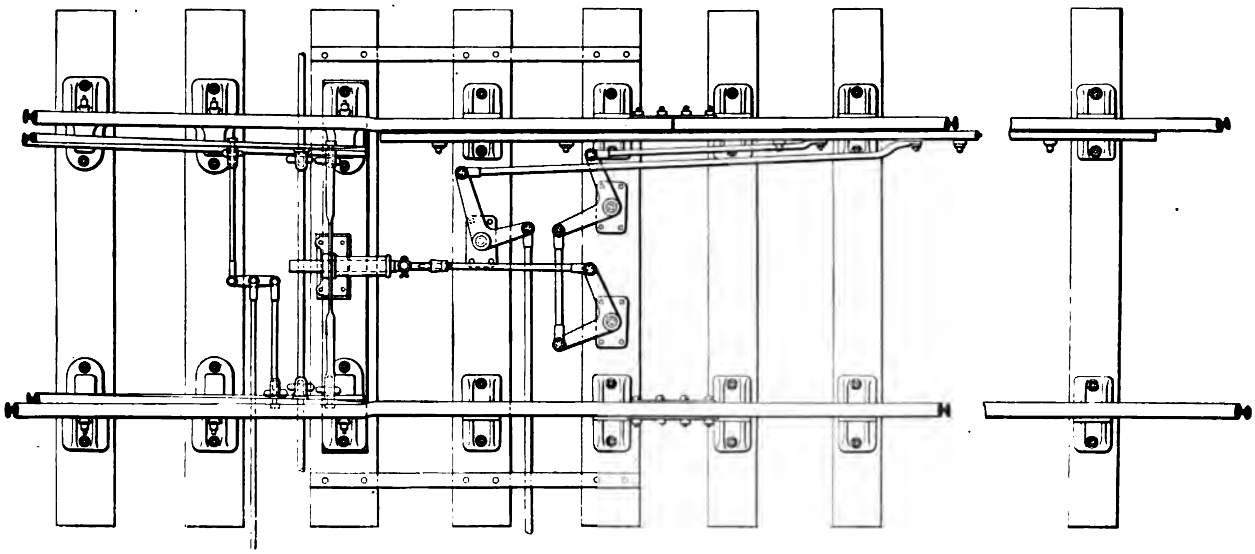
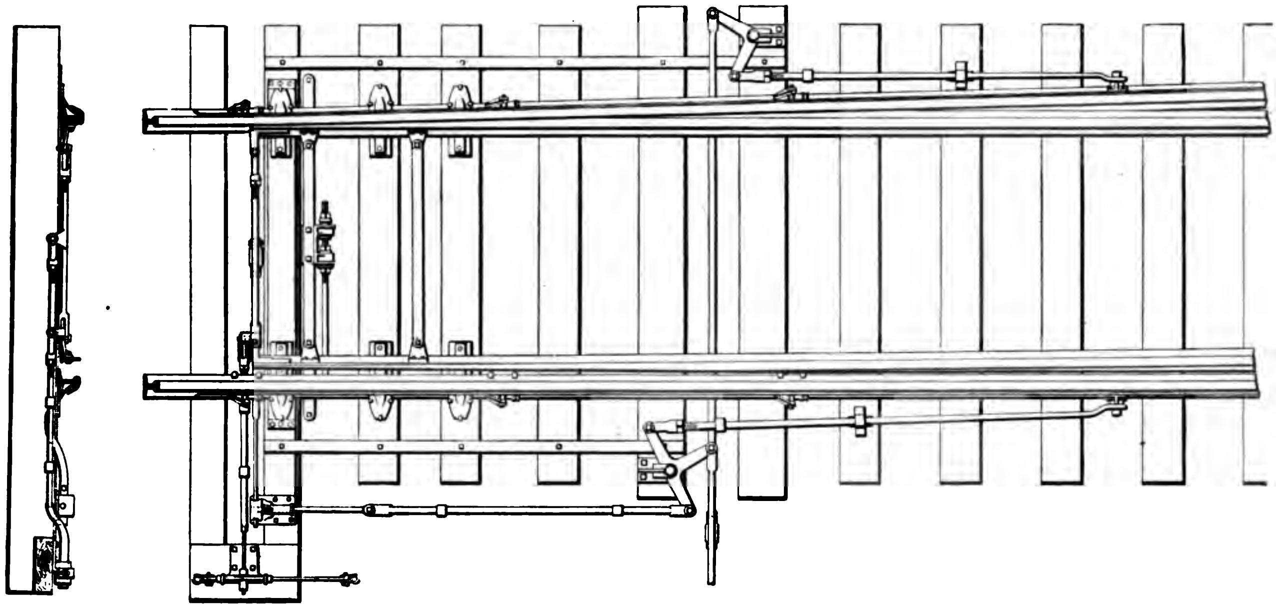
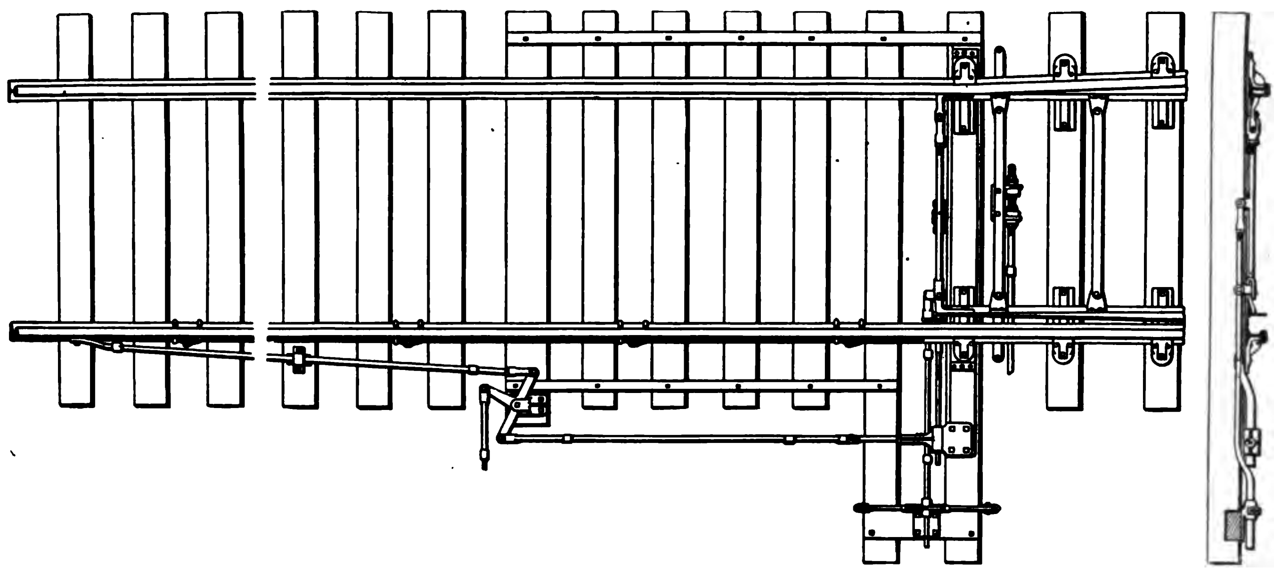


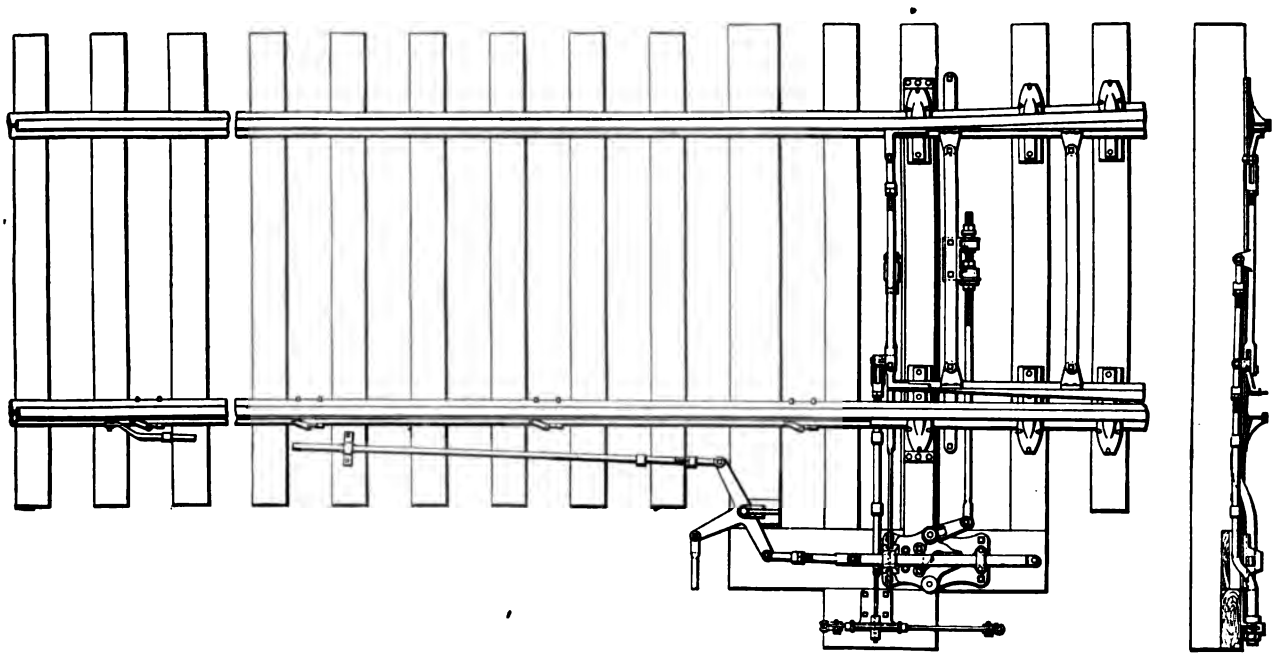
Fig. 911. Inside Connected Facing Point Lock, Throw Rod and Inside Parallel Bar (Detector Bar). Great Western Railway of England.



Figs. 912-913. Outside Connected Facing Point Lock and Switch Connections, with Bolt Lock. Two Detector Bars Behind the Points.



Figs. 914-915. Outside Connected Facing Point Lock and Switch Fittings, with Bolt Lock. Detector Bar Ahead of the Points.



Figs. 916-917. Switch and Lock Movement, Switch Fittings and Bolt Lock. Detector Bar Ahead of Points.

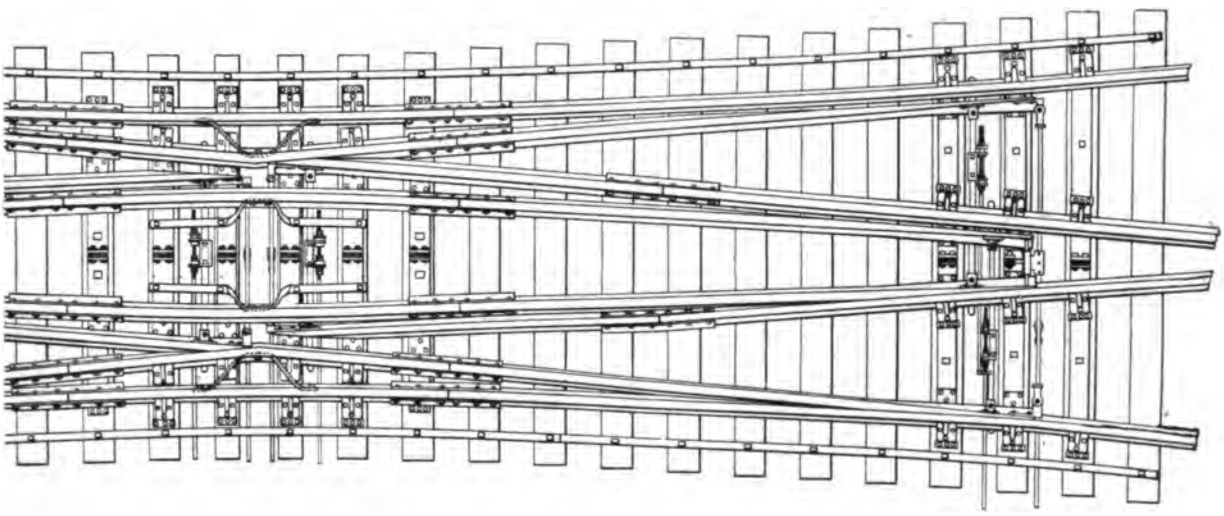


Fig. 918. Method of Plating and Tying Double Slip Switch, with Movable Point Frogs. Detector Bars Not Shown; Tie Plates Insulated. Long Island Railroad.

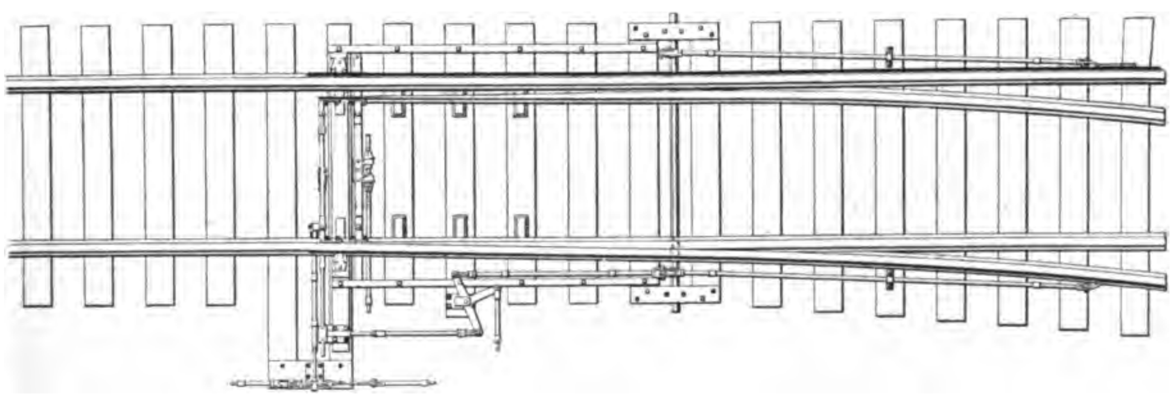
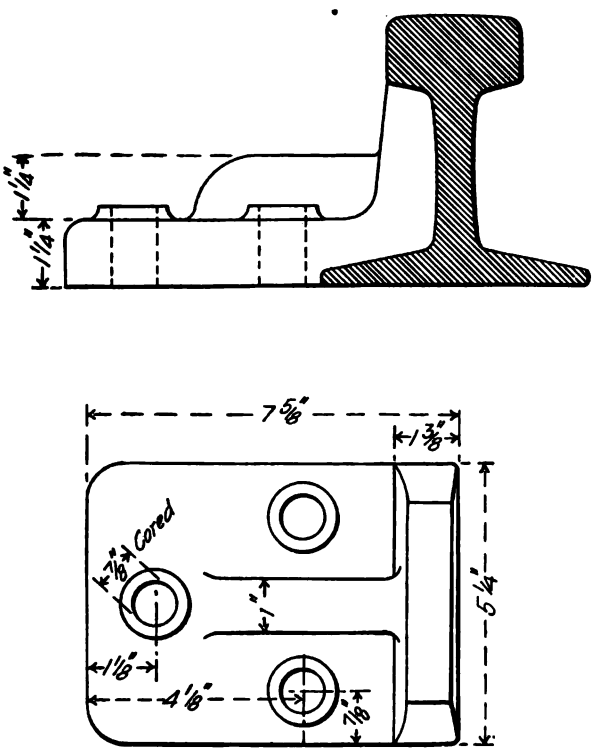


Fig. 919. Outside Connected Facing Point Lock and Switch Fittings, with Bolt Lock. Two Detector Bars Behind Points, Moved by a Rocker Shaft.

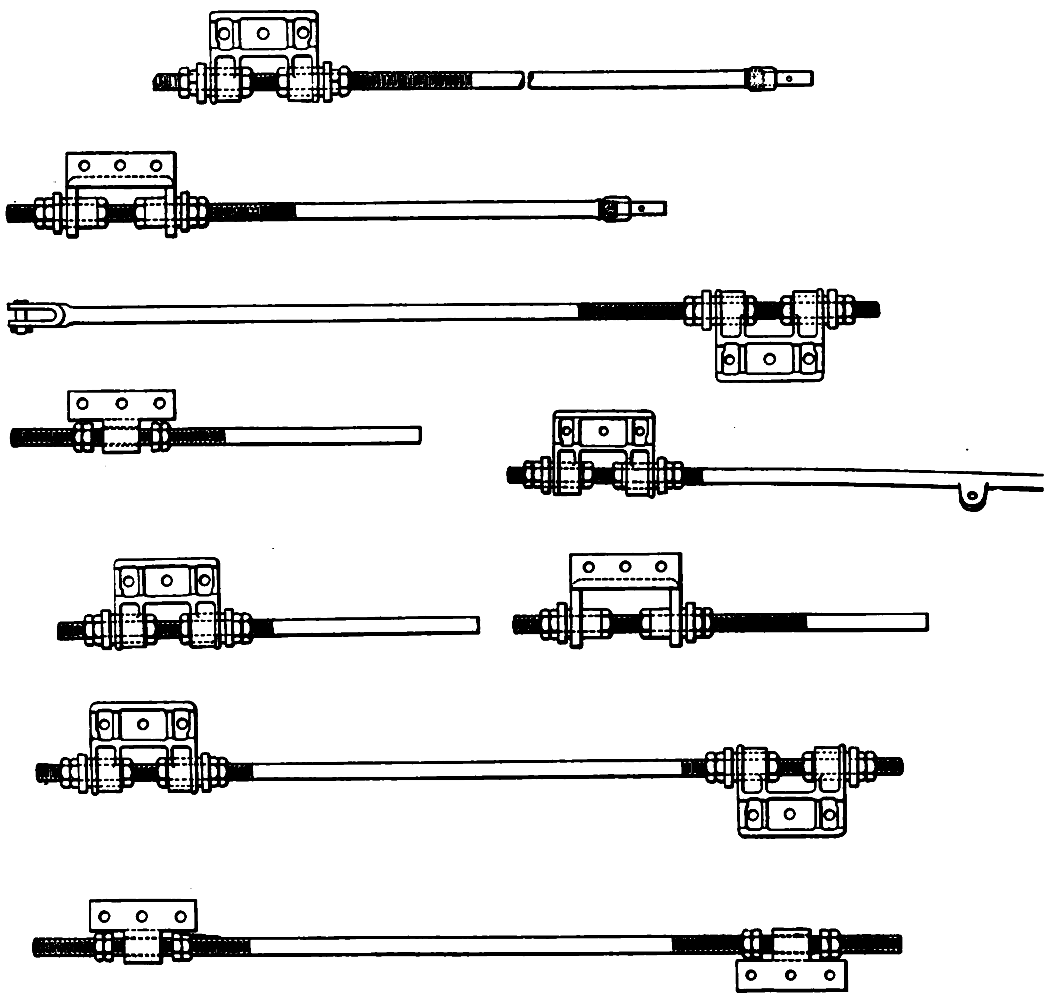


Figs. 920-921. Cast Iron Rail Brace for 100-lb. Rail. Long Island Railroad.

Fig. 922. Rail Brace. The Cleveland Frog & Crossing Co.

Names of Parts of Adjustable Lock Rods; Figs. 932-937.

A *Adjustable Lock Rod for Switch and Lock Movement Figs.* 888-889
B *Adjustable Lock Rod for Facing Point Lock*
1 *Lock Rod*
2 *Adjusting Lock Plate, Right Hand*
2a *Adjusting Lock Plate, Left Hand*
3 *¾" x 2¾" Bolt and Nut*
4 *¾" Washer*
5 *Adjusting Sleeve*
6 *Jam Nut*
7 *Jam Nut*
8 *1¼" Screw Jaw*
9 *⅞" x 2⅝" Pin and Cotter*
10 *Lock Rod*
11 *Adjustable Locking Plate*



*Figs. 923-931. Throw Rods and Switch Adjustments.

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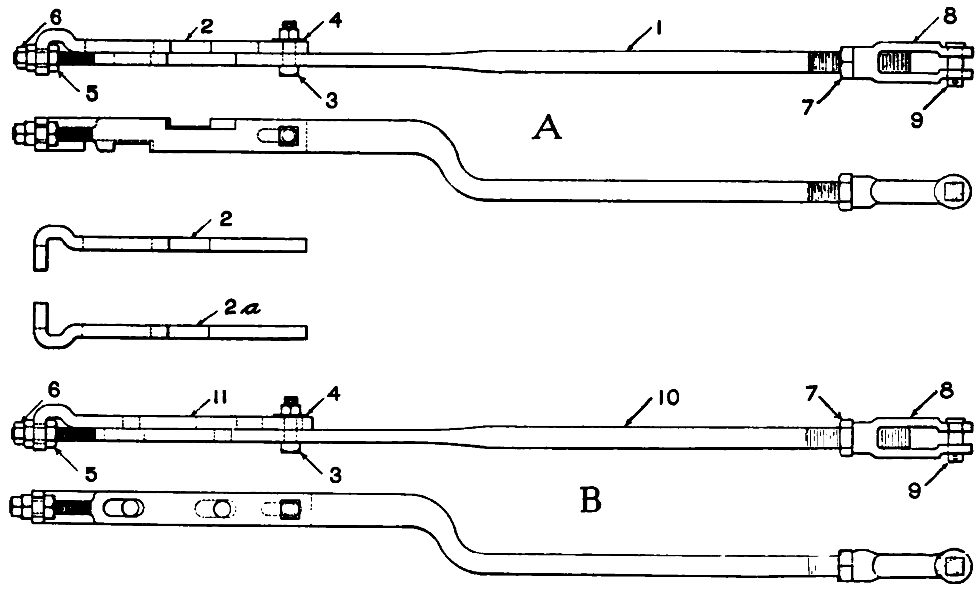
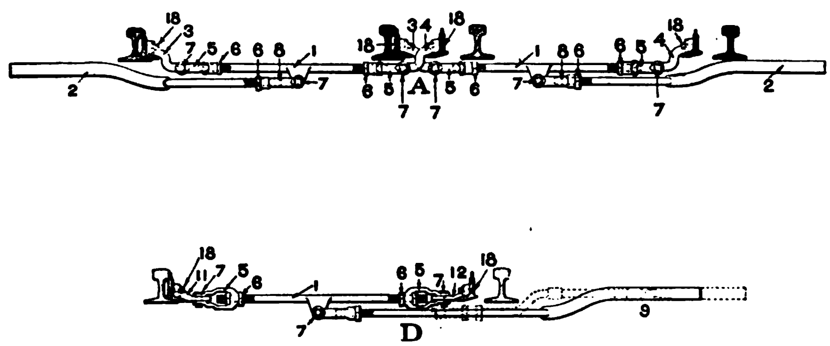


*Figs. 932-937. Adjustable Lock Rods.



*Figs. 938-939. Front and Lock Rods.

Names of Parts of Front and Lock Rods; Figs. 938-939.

A *Front and Lock Rod for Double Slip Switch*

D *Front and Lock Rod for Switch with Switch and Lock Movement*

1 *Front Rod*

2 *Lock Rod*

3 *Left Hand Point Lug*

4 *Right Hand Point Lug*

5 *1¼-in. Screw Jaw*

6 *1½-in. Jam Nut*

7 *⅞" x 2⅜" Pin and Cotter*

8 *1¼-in. Screw Jaw*

11 *Left Hand Point Lug*

12 *Right Hand Point Lug*

18 *⅝" x 2⅜" C. S. H. Bolt*

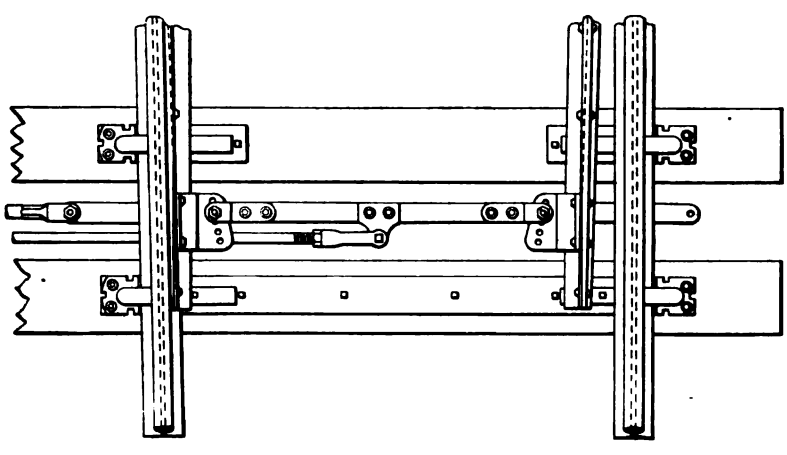
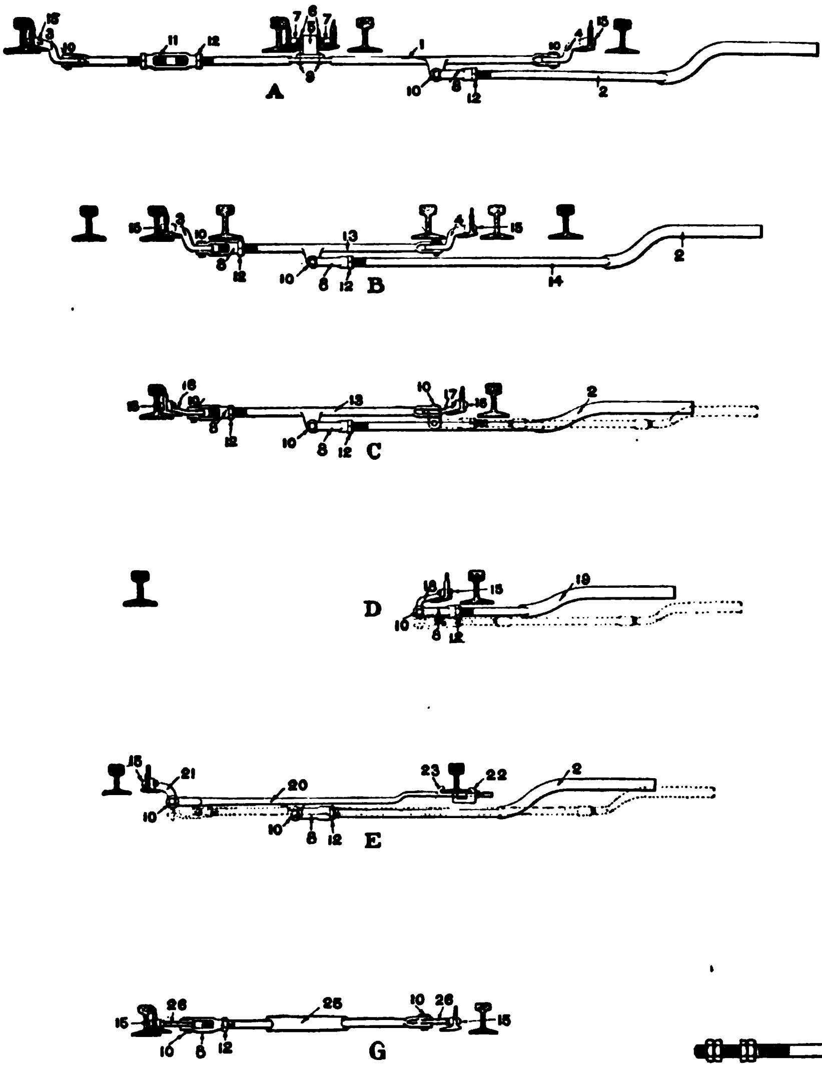


Fig. 940. Switch Adjustment. Southern Pacific-Union Pacific.

Thus, should the throw rod become disconnected the switch could not be falsely locked. For use at derails, where it is necessary to lock only one way, a special form of switch and lock movement may be used (Figs. 886-887). Another form of movement (Figs. 884-885), requires a separate plunger casting, having two plungers entering from opposite ends (Figs. 908-909) known as a duplex lock, connected directly to the pipe line. A switch layout with switch and lock movement may be seen in Figs. 916-917. The weak point of the switch and lock movement is the small amount of motion available for locking the switch. Consequently, owing to the spring and lost motion in the connections, a lever might be fully reversed without causing the movement to complete its stroke. Also the one pipe line becoming disconnected might cause a dangerous condition at the switch without being discovered at once by the signalman; whereas, with the facing point lock, if the pipe line which throws the switch should become disconnected, the chances are that he would discover the fact when he tried to reverse the lock lever, before any train could pass over the switch.

In order to allow for lost motion and future adjustment, the throw in the pipe line which moves the switch is usually made greater than that of the switch itself. To provide for this over stroke, switch adjustments or "cages" (Figs. 923-931) are used. The throw rod is threaded for a considerable distance and passes through thimbles in the "cage." Nuts are checked up against each side of the thimbles which in turn engage the "cage" and throw the switch. Lock rods may have fixed notches or holes or may be adjustable (Figs. 932-937).

In order to hold switch points and stock rails securely in place

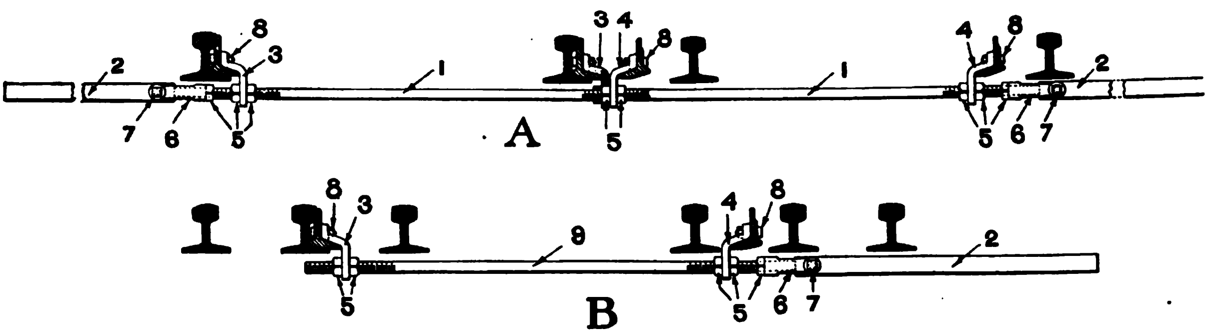


*Figs. 941-946. Front and Lock Rods.

Names of Parts for Front and Lock Rods; Figs. 941-946.

A *Front and Lock Rod for Double Slip Switch*
B *Front and Lock Rod for Movable Point Frog*
C *Front and Lock Rod for Single Switch*
D *Lock Rod for Derail*
E *Front and Lock Rod for Derail*
G *Front and Lock Rod Combined for Inside Connected Facing Point Lock*
1 *Front Rod with Turnbuckle*
2 *Lock Rod*
3 *Left Hand Point Lug*
4 *Right Hand Point Lug*
5 *Point Separator*
6 *1-in. Jam Nut*
7 *1-in. Adjusting Screw*
8 *1¼-in. Screw Jaw*
9 *⅝" x 1⅜" Rivet*
10 *⅞" x 2⅜" Pin and Cotter*
11 *Turnbuckle*
12 *1¼-in. Jam Nut*
13 *Front Rod*
14 *Lock Rod*
15 *⅝" x 2⅜" Bolt*
16 *Left Hand Point Lug*
17 *Right Hand Point Lug*
18 *Right Hand Point Lug*
19 *Lock Rod*
20 *Front Rod*
21 *Left Hand Point Lug*
22 *Guide Clip*
23 *Hook Bolt*
25 *Front and Lock Rod*
26 *Right or Left Hand Point Lug*

*Fig. 947. Special Front Rod.



*Figs. 948-949. Front and Lock Rods.

Names of Parts of Front and Lock Rods; Figs. 948-949.

A *Front and Lock Rods for Double Slip Switch*
B *Front and Lock Rods for Movable Point Frog*
1 *Front Rod*
2 *Lock Rod*
3 *Left Hand Single Point Lug*
4 *Right Hand Single Point Lug*
5 *1¼-in. Jam Nut*
6 *1¼-in. Screw Jaw*
7 *⅞" x 2⅜" Pin and Cotter*
8 *⅝" x 2⅜" Bolt*
9 *Front Rod*

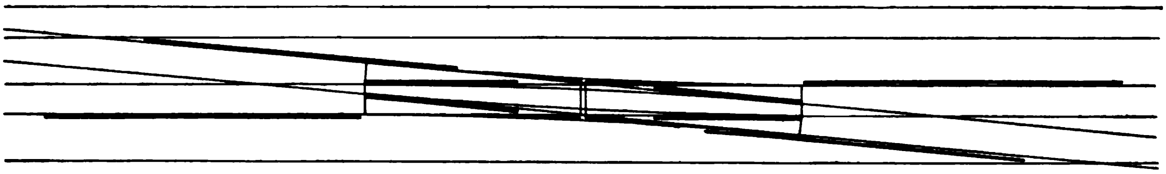


Fig. 950. Detector Bars, with Double Slip Switch. New York Central & Hudson River.

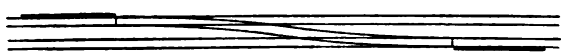


Fig. 951. Standard Detector Bar Layout at Cross-over. New York Central & Hudson River.

Fig. 952. Standard Detector Bar Layout at Cross-over on Curve; Bars Behind Points. New York Central & Hudson River.

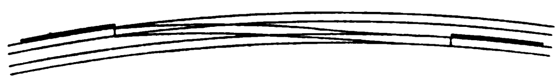


Fig. 953. Standard Detector Bar Layout at Cross-over on Curve; Bars Ahead of Points. New York Central & Hudson River.

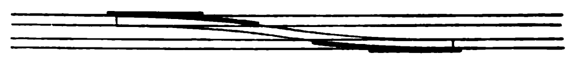
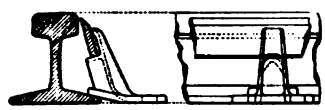


Fig. 954. Standard Detector Bar Layout at Cross-over; Bars Behind Points. New York Central & Hudson River.

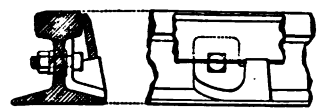
Figs. 955-956. Rail Clips, Detector Bar Stops and Detector Bars. The Union Switch & Signal Co.

Names of Parts for Detector Bars, Stops, Guides and Rail Clips; Union Switch & Signal Company; Figs. 955-956.

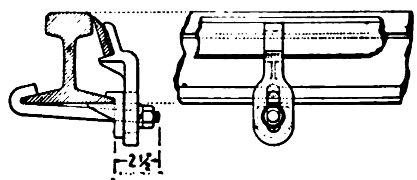
1 *Rail Clip, Model* 1
2 *Rail Clip, Model* 2
3 *Rail Clip, Model* 3
4 *Rail Clip, Model* 4
13 *Adjustable Stop and Guide*
14 *Adjustable Stop with Hook Bolt*
15 *Adjustable Stop with Hook or Web Bolt*



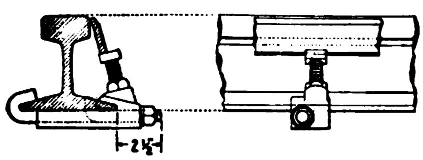
*Figs. 957-958. Detector Bar Stop and Guide, to be Fastened to the Tie.



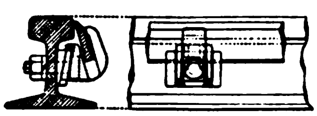
*Figs. 959-960. Detector Bar Stop, Bolted Through Web of Rail.



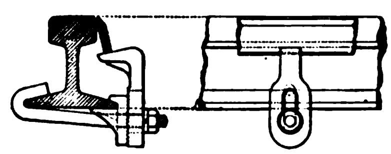
*Figs. 961-962. Adjustable Detector Bar Stop and Guide, Clamped to Base of Rail.



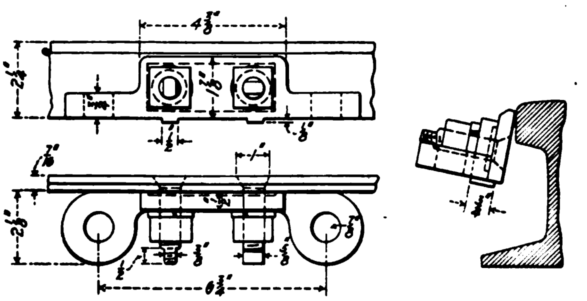
*Figs. 963-964. Adjustable Detector Bar Stop, Clamped to Base of Rail.



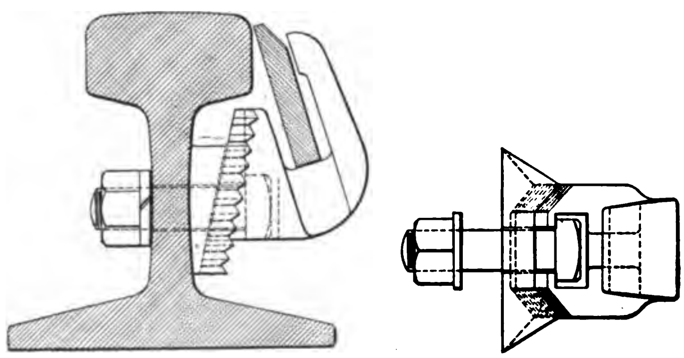
*Figs. 965-966. Detector Bar Stop and Guide, Bolted Through Web of Rail.



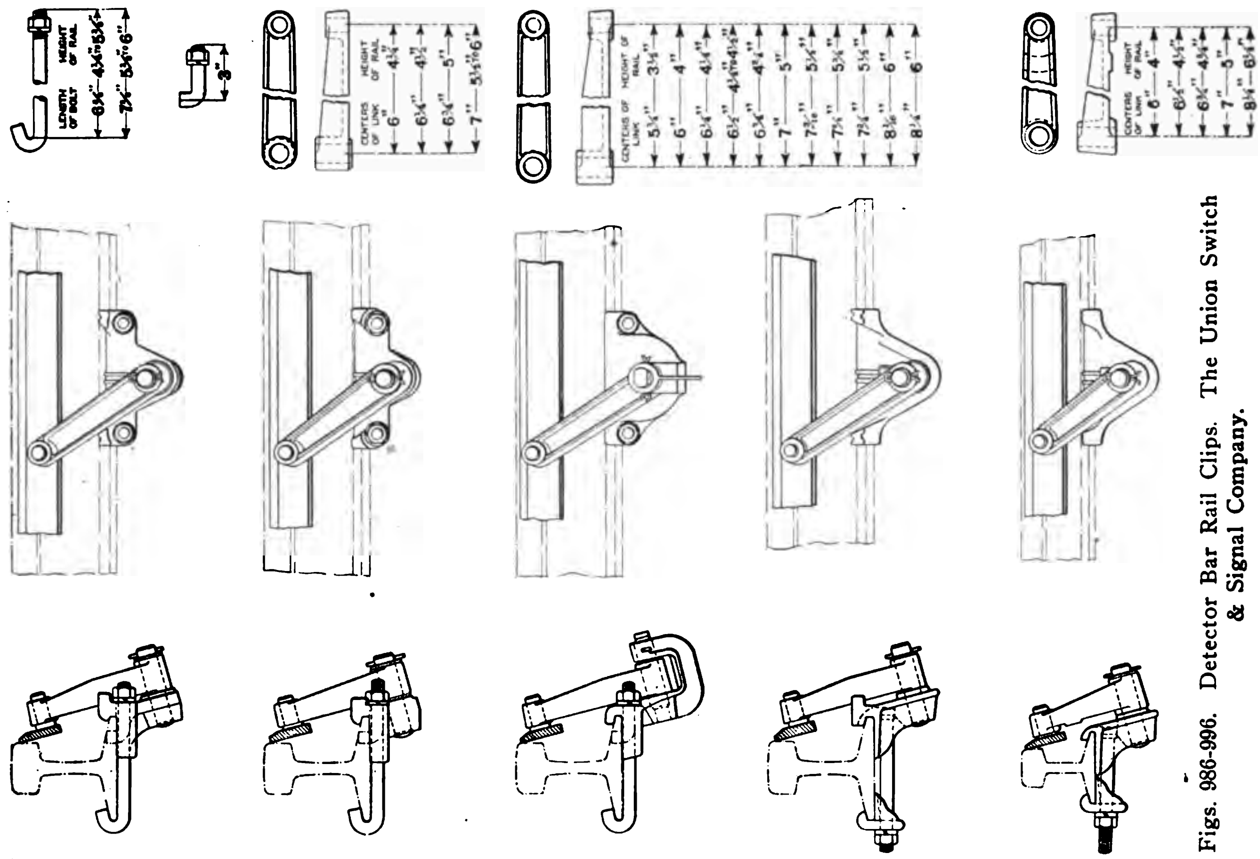
*Figs. 967-968. Adjustable Detector Bar Stop. Clamped to Base of Rail.



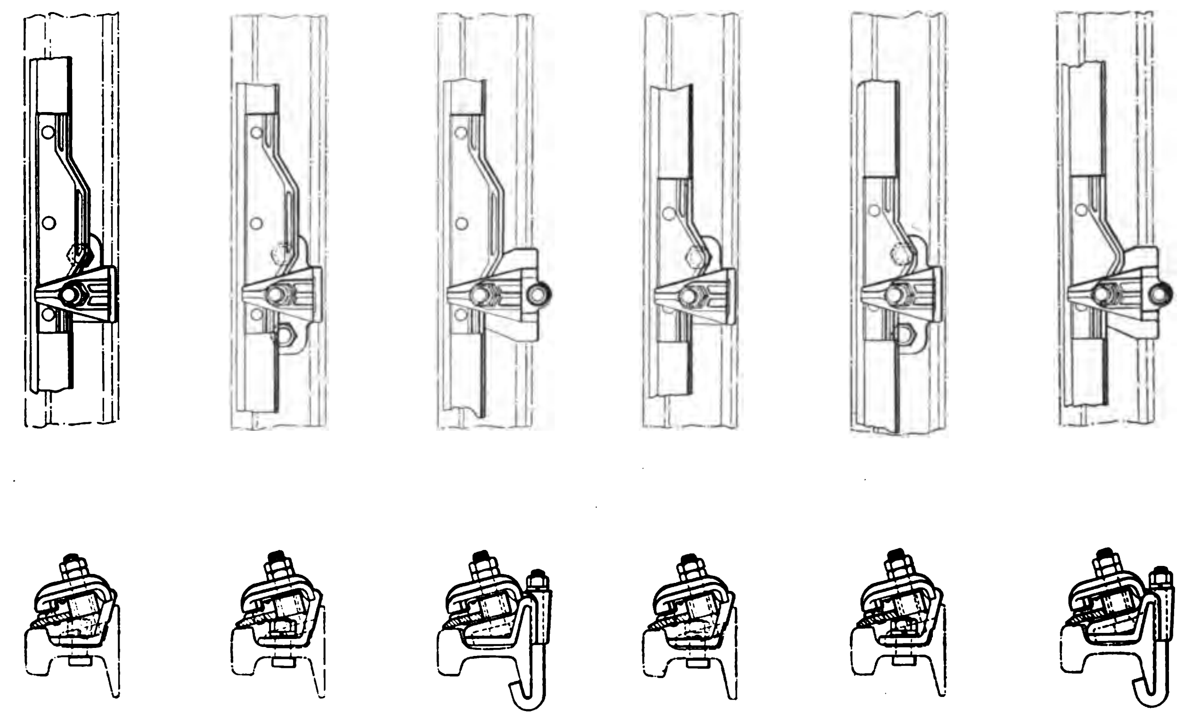
Figs. 969-971. Malleable Iron Detector Bar Driving Piece. Michigan Central.



*Figs. 972-973. Detector Bar Guide and Stop.



Figs. 986-996. Detector Bar Rail Clips. The Union Switch & Signal Company.



*Figs. 974-985. Motion Plate Detector Bar Rail Clips.

New York Central Standard.

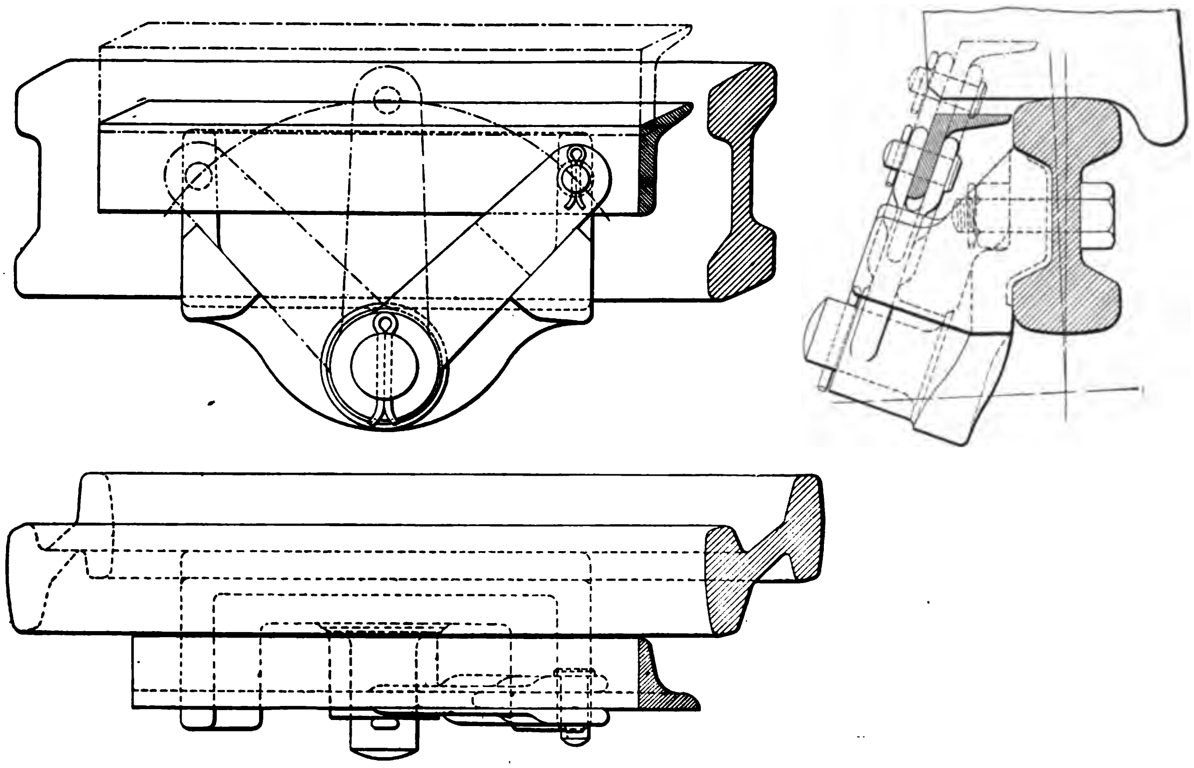
New York Central Standard.

Union Elevated Standard.

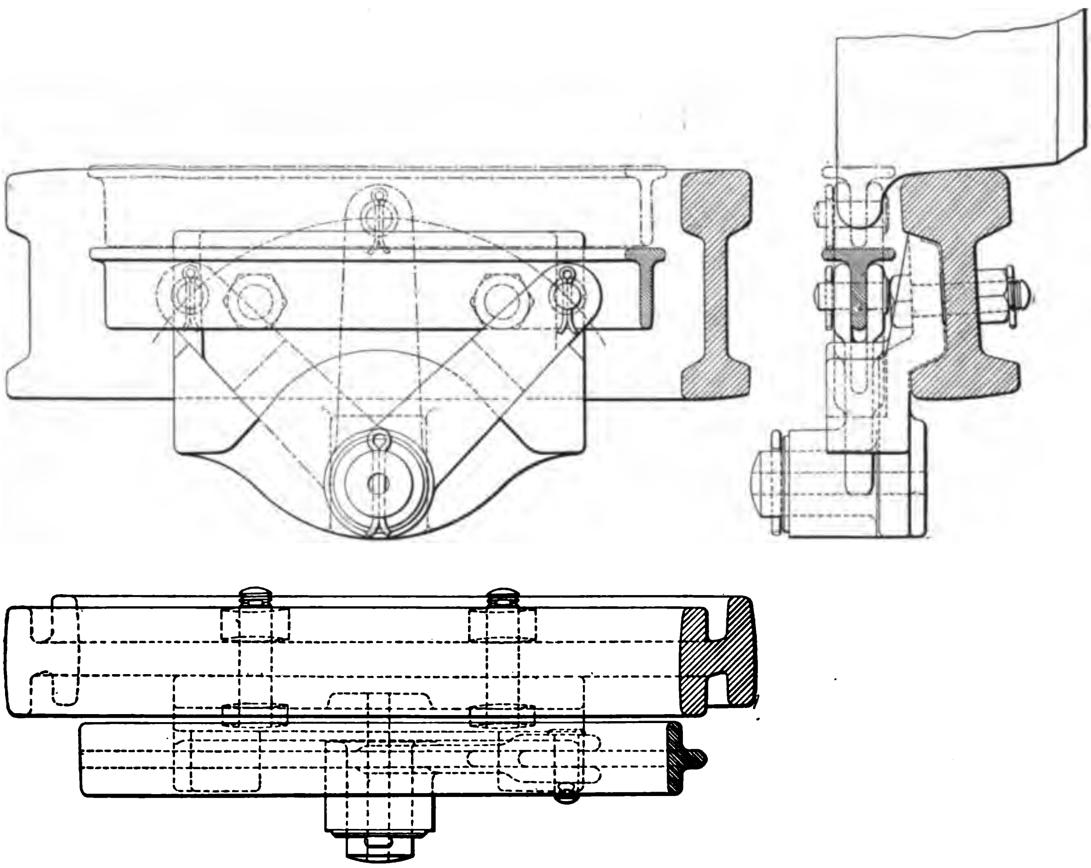
New York Central Standard.

New York Central Standard.

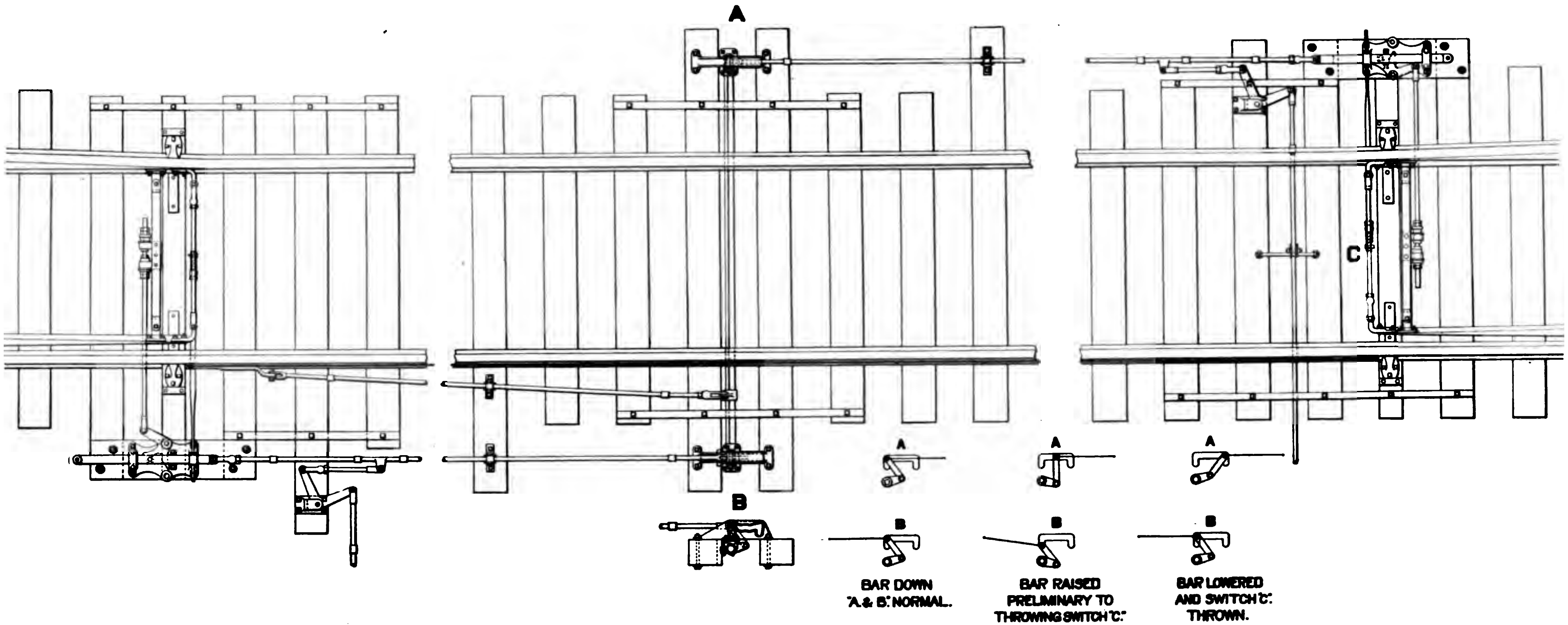
Union Elevated Standard.



Figs. 997-999. Outside Parallel Bar (Detector Bar). Great Western Railway of England.



Figs. 1000-1002. Inside Parallel Bar. Great Western Railway of England.



Figs. 1003-1007. Method of Operating One Detector Bar from Two Points. The General Railway Signal Company.

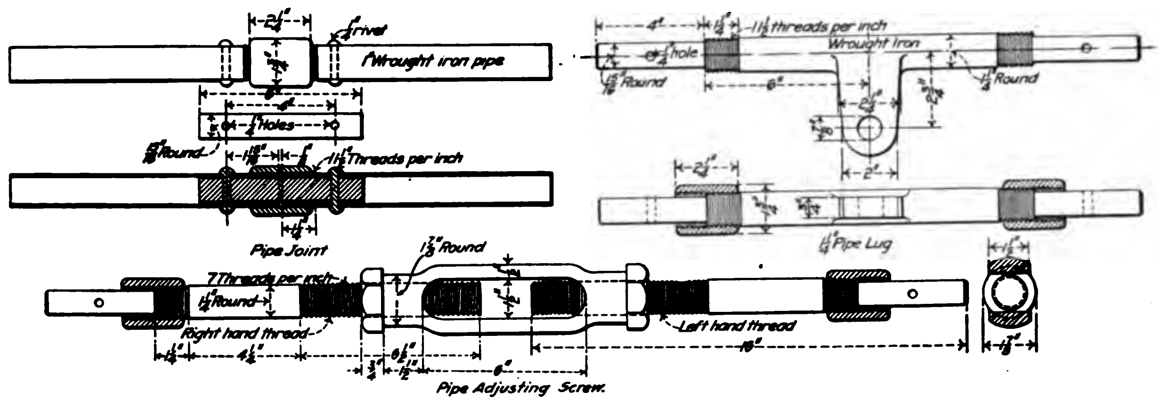
it is necessary to brace the rails at the switch; also one or more tie plates extending across the tracks are fastened to the ties. Fig. 918 shows these fittings applied to a double slip and movable point frog. Rail braces are shown in Figs. 920-922. This construction can be applied equally well to a single switch. In the drawing the rods and plates are shown insulated for track circuits. The plates are made of ½ in. x 6 in. iron. Plunger castings are fastened through the tie plate to the head block.

To prevent signalmen from throwing switches under moving trains detector bars are employed. A detector bar is a piece of iron lying along the rail. It is held in place by clips and guides (Figs. 957-1002), so that whenever it is moved lengthwise the top of it rises above the head of the rail. With such an arrangement it will be seen that if an attempt is made to move the bar while one or more wheels of a train are on the track at that point, the bar will strike against the wheels and cannot be thrown. Detector bars are made longer than the maximum distance between the wheels of a car in order that they may not rise between trucks. The bar is actuated by the same rod that operates the plunger of a facing point lock, or by the operating rod of a switch and lock movement. Therefore the bar must rise at the same time the switch is being unlocked. Various arrangements of detector bars at switches are shown in Figs. 910-917 and 950-954. The bar should always be put on the high side of a curve as centrifugal force tends to throw the wheels of a train toward that side. Where a bar cannot be placed ahead of a switch, two bars must be used as shown in Figs. 912-913, 919, 952 and 954, one on each track, thereby insuring that it will be impossible to unlock the switch when either track is occupied. The detector bars may be driven from cranks (Figs. 910-917) or from rocker shafts suspended below the rails. (Fig. 919.)

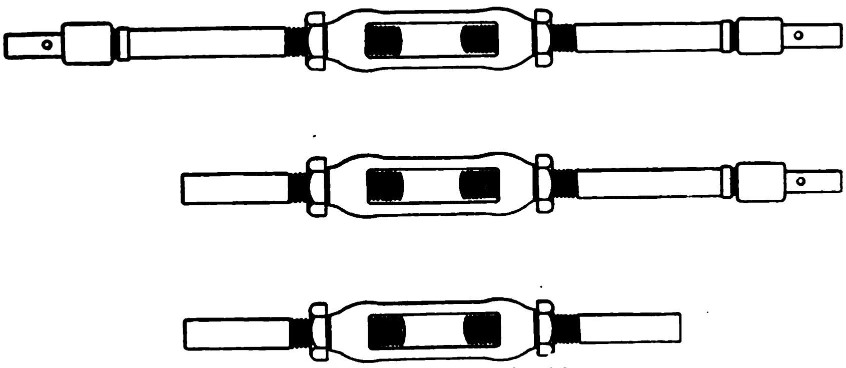
Figs. 1003-1007 show a device for operating one detector bar in connection with two switch and lock movements. At each end of the rocker shaft are arms connected to links, the upper ends of which travel in guides A and B, and are driven by the switch and lock movements. The action of the device can clearly be seen by reference to the small diagrams. The bar in this case moves from its normal position to the center of the stroke and back, never going to the full reverse position.

The connections between the lever of the interlocking machine and its function, through which the motion is imparted, consist of 1 in. iron pipe or No. 9 gage steel wire. Wire is used for signals only. Lengths of pipe are joined together or to jaws by coupling sleeves and rivets through iron plugs or through the tang end of the jaw. Thus a rigid joint is secured which does not depend on the threads. Various pipe and rod connections and adjustments are shown in Figs. 1008-1016 and 1023-1098. The butt or "stub" ends are provided for welding to solid rods.

Pipe is guided and supported by pipe carriers (Figs. 1163-1164 and 1206-1241). They consist of an iron frame carrying wheels or rollers between which the pipe moves. Those in which the hub of the wheel travels in a slot are known as anti-function pipe carriers (Figs. 1207, 1211 and C, E, F, H, N and P, Figs. 1213-1241); sometimes the roller also is made anti-function. These pipe



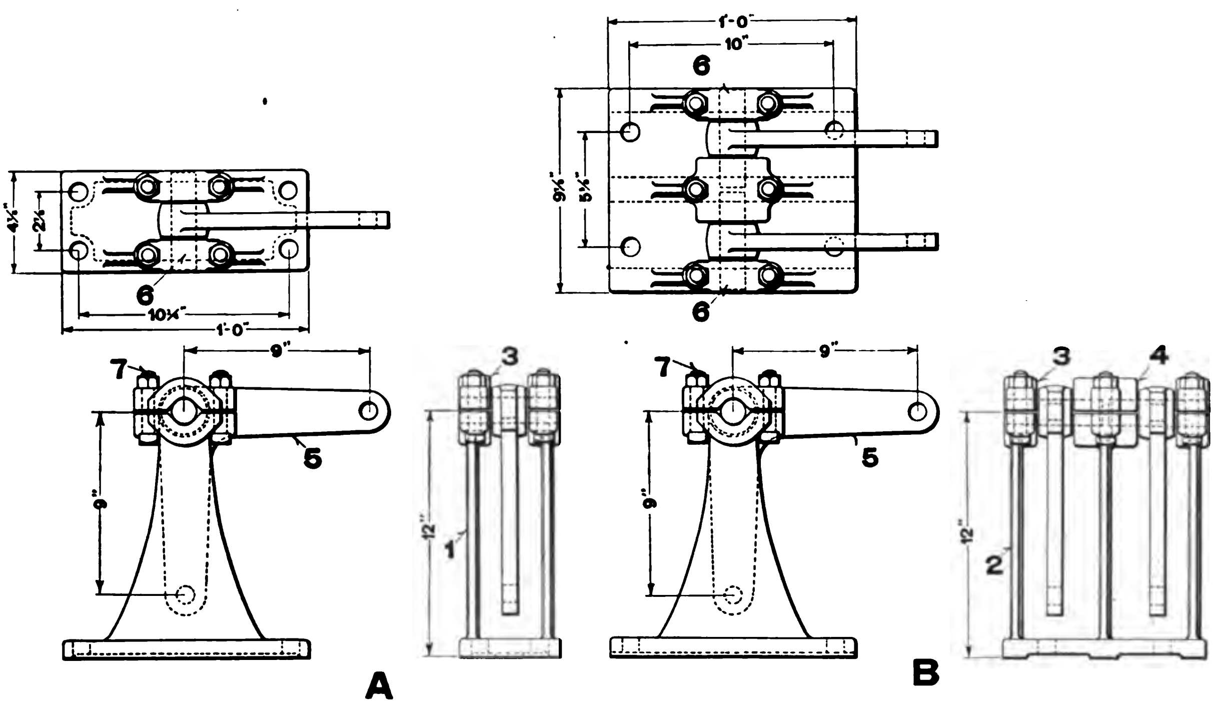
Figs. 1008-1013. Details of Pipe Joint, Tang End Lug and Turnbuckle. Baltimore & Ohio.



*Figs. 1014-1016. Turnbuckles.

Names of Parts of Vertical Cranks and Stands. Figs. 1017-1022.

A *One Way Vertical Leadout Crank, Split Bearings*
B *Two Way Vertical Leadout Crank, Split Bearings*
1 *One Way Vertical Crank Stand*
2 *Two Way Vertical Crank Stand*
3 *Nut*
4 *Wide Bearing Cap*
5 9" x 9" *Crank*
6 *Bearing Cap*
7 *Bolt*

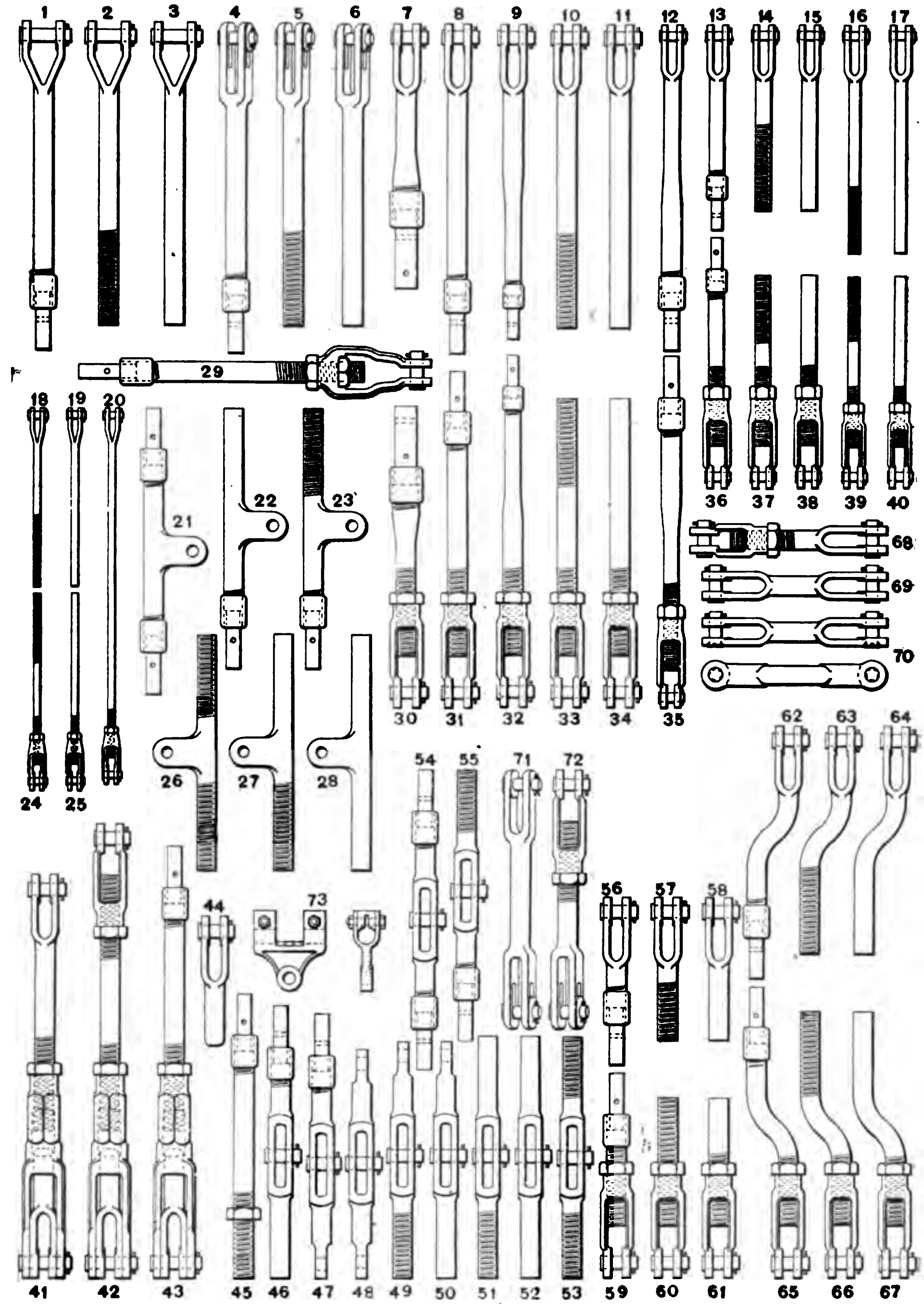


*Figs. 1017-1022. Vertical Cranks and Stands.

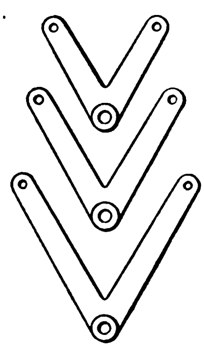
carriers are fastened by lag screws to long ties or to foundations. They may be made in units to be mounted side by side or in groups of any required number. The foundations may consist of concrete to which a block of wood is attached (Figs. 1192-1196), or of iron legs bolted to two wooden blocks. They are set in the ground a sufficient distance from the nearest rail to provide clearance for the carriers (Fig. 1197). Carriers are usually spaced not more than 8 ft. apart as the pipe is under strain both in tension and compression. Where pipe lines cross the track, transverse or hanging pipe carriers are used (Figs. 1163-1164 and G, K and L, Figs. 1213-1241) lagged to the ties.

Where it is necessary to change the direction of a pipe run,

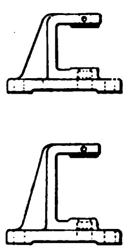
Numbers Refer to List of Names of Parts on Opposite Page.



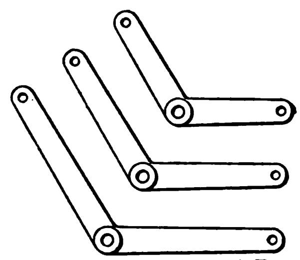
*Figs. 1023-1098. Jaws, Pipe Line Lugs and Links.



*Figs. 1099-1101. 60-Deg. Cranks.



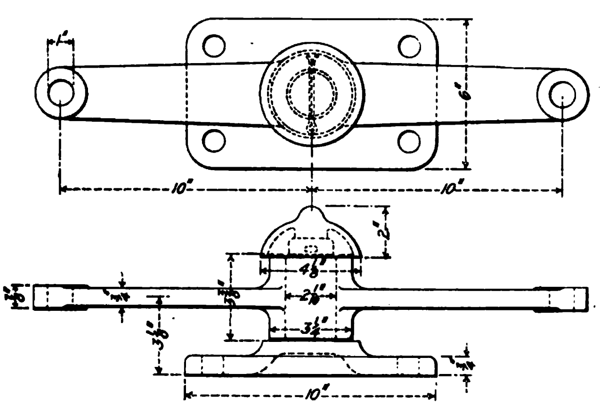
*Figs. 1102-1103. One and Two Way Crank Stands.



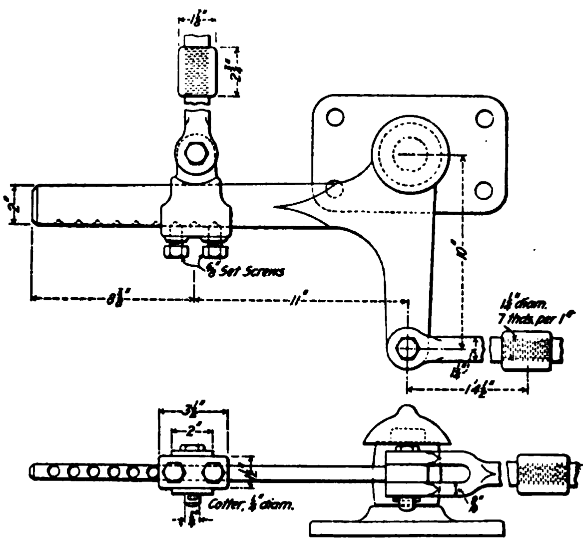
*Figs. 1104-1106. 120-Deg. Cranks.

Names of Parts; Figs. 1023-1098.

1 *Tang End Wide Jaw, 1¼-in.*
2 *Threaded End Wide Jaw, 1¼-in.*
3 *Butt End Wide Jaw, 1¼-in.*
4 *Tang End Slotted Jaw, 1¼-in.*
5 *Threaded End Slotted Jaw, 1¼-in.*
6 *Butt End Slotted Jaw, 1¼-in.*
7 *Tang End Transition Jaw, 1¼-in. to 1-in.*
8 *Tang End Jaw, 1¼-in.*
9 *Tang End Transition Jaw, 1-in. to 1¼-in.*
10 *Threaded End Jaw, 1¼-in.*
11 *Butt End Jaw, 1¼-in.*
12 *Tang End Transition Jaw, 1¼-in. to 1-in.*
13 *Tang End Jaw, 1-in.*
14 *Threaded End Jaw, 1-in.*
15 *Butt End Jaw, 1-in.*
16 *Threaded End Jaw, ¾-in.*
17 *Butt End Jaw, ¾-in.*
18 *Threaded Up and Down Rod with Jaw, ½-in.*
19 *Butt End Up and Down Rod with Jaw, ½-in.*
20 *Up and Down Rod with Plain and Screw Jaw, ½-in.*
21 *Tang End Lug*
22 *Butt and Tang End Lug*
23 *Threaded and Tang End Lug*
24 *Threaded Up and Down Rod with Screw Jaw, ½-in.*
25 *Butt End Up and Down Rod with Screw Jaw, ½-in.*
26 *Threaded End Lug*
27 *Butt and Threaded End Lug*
28 *Butt End Lug*
29 *Tang End Clevis Nut, 1¼-in.*
30 *Tang End Transition Screw Jaw, 1¼-in. to 1-in.*
31 *Tang End Screw Jaw, 1¼-in.*
32 *Tang End Transition Screw Jaw, 1-in. to 1¼-in.*
33 *Threaded End Screw Jaw, 1¼-in.*
34 *Butt End Screw Jaw, 1¼-in.*
35 *Tang End Transition Screw Jaw, 1¼-in. to 1-in.*
36 *Tang End Screw Jaw, 1-in.*
37 *Threaded End Screw Jaw, 1-in.*
38 *Butt End Screw Jaw, 1-in.*
39 *Threaded End Screw Jaw, ¾-in.*
40 *Butt End Screw Jaw, ¾-in.*
41 *Gain Stroke Jaw with Plain Jaw, 1¼-in.*
42 *Gain Stroke Jaw with Screw Jaw, 1¼-in.*
43 *Tang End Stroke Jaw, 1¼-in.*
44 *Butt End Jaw, 1¼-in.*
45 *Tang End Threaded Rod, 1¼-in.*
46 *Tang and Butt End Double Jaw, 1¼-in.*
47 *Tang End Double Jaw with Eye, 1¼-in.*
48 *Double Jaw with Two Eyes, 1¼-in.*
49 *Threaded End Double Jaw with Eye, 1¼-in.*
50 *Butt End Double Jaw with Eye, 1¼-in.*
51 *Butt and Threaded End Double Jaw, 1¼-in.*
52 *Butt End Double Jaw, 1¼-in.*
53 *Threaded End Double Jaw, 1¼-in.*
54 *Tang End Double Jaw, 1¼-in.*
55 *Tang and Threaded End Double Jaw, 1¼-in.*
56 *Tang End Jaw, 1¼-in.*
57 *Threaded End Jaw, 1¼-in.*
58 *Butt End Jaw, 1¼-in.*
59 *Tang End Screw Jaw, 1¼-in.*
60 *Threaded End Screw Jaw, 1¼-in.*
61 *Butt End Screw Jaw, 1¼-in.*
62 *Tang End Offset Jaw, 1¼-in.*
63 *Threaded End Offset Jaw, 1¼-in.*
64 *Butt End Offset Jaw, 1¼-in.*
65 *Tang End Offset Screw Jaw, 1¼-in.*
66 *Threaded End Offset Screw Jaw, 1¼-in.*
67 *Butt End Offset Screw Jaw, 1¼-in.*
68 *Adjustable Link, 1¼-in.*
69 *Solid Link, 1¼-in.*
70 *Solid Link, 1¼-in.*
71 *Solid Link with Slotted Jaw, 1¼-in.*
72 *Adjustable Link with Slotted Jaw, 1¼-in.*
73 *Clamp Pipe Lug*



Figs. 1107-1108. Straight Arm Compensator. Great Western of England.



Figs. 1109-1110. Adjustable Crank. Great Western of England.

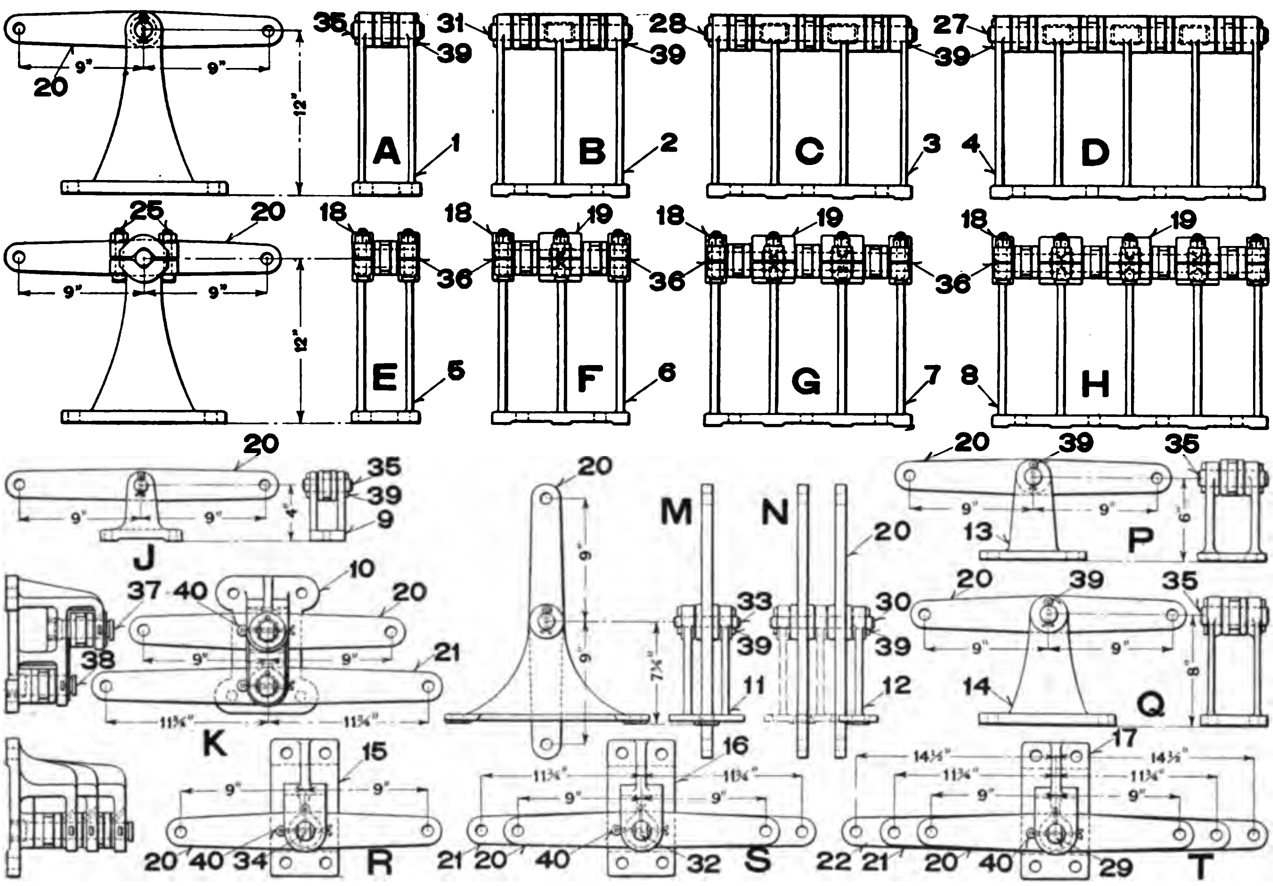
cranks of various angles (Figs. 1017-1022, 1099-1135 and 1149-1162) are used according to circumstances. Where the angle is not sharp enough to require cranks, radial arms (Figs. 1165-1184, J, K and M) or deflecting bars (Figs. 1165-1184, A-H) may be used. The former consists of a one armed crank and the latter, a curved rod moving in suitable guides.

PIPE COMPENSATION.

The connection between a lever and its function being equivalent to a solid iron rod, expansion and contraction will accompany change in temperature. Provision must be made to overcome the effects of such expansion and contraction, as otherwise on a warm day the pipe line would be too long and on a cold day too short. This would prevent levers and their functions from making full stroke in one direction or the other. Serious variations in length might take place between morning and noon. For this reason *compensators* are used. A compensator reverses the direction of travel in the pipe line so that expansion or contraction in different portions of the line counteract each other. Where there are no branch lines and only one compensator is used, it should be placed midway between the lever and its function. Should there be branch lines, as when two functions are operated from one lever, one compensator should be placed midway between the end of the shorter branch and the lever; and a second compensator should be placed a distance from the end of the longer branch equal to half the difference in length of the two branches. Three or more branches can be treated in a similar manner. If two or more compensators are to be used and there are no branches, they should not be evenly spaced, but each should be in the middle of the section of the pipe line to be compensated. For instance, if two are used, one should be placed a distance from the lever equal to one-quarter the length of the line, and the second the same distance from the function. A compensator may consist of a straight crank (Figs. 1107-1108, 1111-1135 and D, E and F, Figs. 1149-1162), or a "lazy-jack" (Figs. 1136-1148 and 1606-1609). The latter consists of two cranks, one at 60 degrees, the other at 120 degrees, mounted on a base and connected by a short link. By using this device

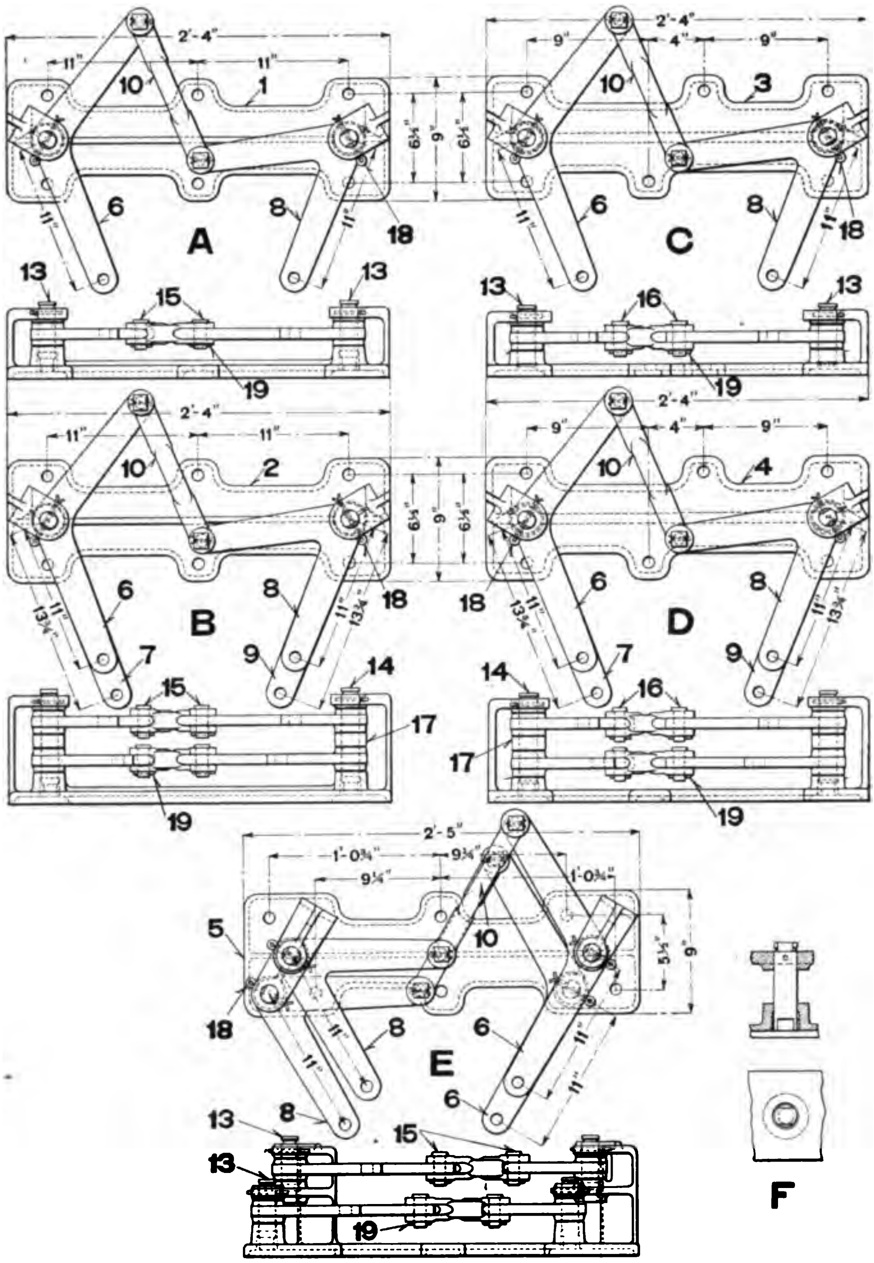
Names of Parts. Straight Arm Compensators. Figs. 1111-1135.

A *One Way High Compensator, Vertical Stand*
B *Two Way High Compensator, Vertical Stand*
C *Three Way High Compensator, Vertical Stand*
D *Four Way High Compensator, Vertical Stand*
E *Same as* **A**, *With Split Bearings*
F *Same as* **B**, *With Split Bearings*
G *Same as* **C**, *With Split Bearings*
H *Same as* **D**, *With Split Bearings*
J *Low Compensator, Vertical Stand*
K *Two Way Horizontal Compensator, Separate Pin Type*
M *One Way Vertical Compensator*
N *Two Way Vertical Compensator*
P *Low Compensator, Vertical Stand*
Q *Medium Height Compensator, Vertical Stand*
R *One Way Horizontal Compensator*
S *Two Way Horizontal Compensator*
T *Three Way Horizontal Compensator*



*Figs. 1111-1135. Straight Arm Pipe Compensators.

1 *Stand for* **A**
2 *Stand for* **B**
3 *Stand for* **C**
4 *Stand for* **D**
5 *Stand for* **E**
6 *Stand for* **F**
7 *Stand for* **G**
8 *Stand for* **H**
9 *Stand for* **J**
10 *Stand for* **K**
11 *Stand for* **M**
12 *Stand for* **N**
13 *Stand for* **P**
14 *Stand for* **Q**
15 *Stand for* **R**
16 *Stand for* **S**
17 *Stand for* **T**
18 *End Bearing Cap*
19 *Wide Bearing Cap*
20 9" x 9" *Straight Crank*
21 11¾" x 11¾" *Straight Crank*
22 14½" x 14½" *Straight Crank*
25 *Bolt*
27 *Center Pin for* **D**
28 *Center Pin for* **C**
30 *Center Pin for* **N**
31 *Center Pin for* **B**
32 *Center Pin for* **S**
33 *Center Pin for* **M**
34 *Center Pin for* **R**
35 *Center Pin for* **A, J, P, Q**
36 *Center Pin for* **E, F, G, H**
37 *Long Center Pin for* **K**
38 *Short Center Pin for* **K**
39 *Cotter*
40 *Cotter*



*Figs. 1136-1146. Horizontal Lazy Jack Pipe Compensators.

Names of Parts. Lazy Jack Compensator. Figs. 1136-1146.

- **A** *One Way Horizontal Compensator, Center Bolt Holes in Line*
- **B** *Two Way Horizontal Compensator, Center Bolt Holes in Line*
- **C** *One Way Horizontal Compensator, Center Bolt Holes Staggered*
- **D** *Two Way Horizontal Compensator, Center Bolt Holes Staggered*
- **E** *Two Way Horizontal Compensator. Separate Pin Type*
- **F** *Detail of Crank Pin*
- **1** *Stand for* **A**
- **2** *Stand for* **B**
- **3** *Stand for* **C**
- **4** *Stand for* **D**
- **5** *Stand for* **E**
- **6** 11" x 11" *Obtuse Angle Crank*
- **7** 11" x 13¾" *Obtuse Angle Crank*
- **8** 11" x 11" *Acute Angle Crank*
- **9** 11" x 13¾" *Acute Angle Crank*
- **10** *Connecting Link*
- **13** *One Way Crank Pin*
- **14** *Two Way Crank Pin*
- **15** ⅞" x 2⅜" *Pin*
- **16** ⅞" x 2⅜" *Pin*
- **17** *Spacing Washer*
- **18** *Cotter*
- **19** *Cotter*

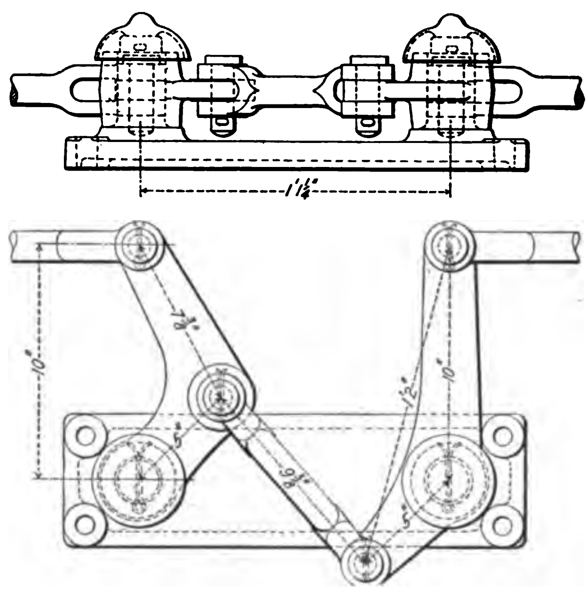
the pipe can be continued in a straight line while the direction of its motion is reversed. Sometimes it is possible to compensate a pipe line by using one or more cranks, so arranged as to reverse the motion.

It is customary in connecting up pipe lines to set all apparatus "on center" so that the throw may be equal in each direction, but to provide proper compensation and take care of all temperature effects the table shown in connection with Figs. 1282-1284, should be used, cutting the pipe long when the temperature is above the mean and short when below. In this way the throw will be equalized. Otherwise the throw of the cranks will be further on one side of center in warm weather than on the other side in cold weather. Figs. 1282-1284 show diagrammatically the effects of temperature on pipe lines. The coefficient of expansion of iron, .008 in. per 100 ft. 1 degree F., is used as the basis of the table and diagram. If the mean temperature of the locality in which the plant is situated is other than 40 degrees, it should be ascertained and the table corrected accordingly.

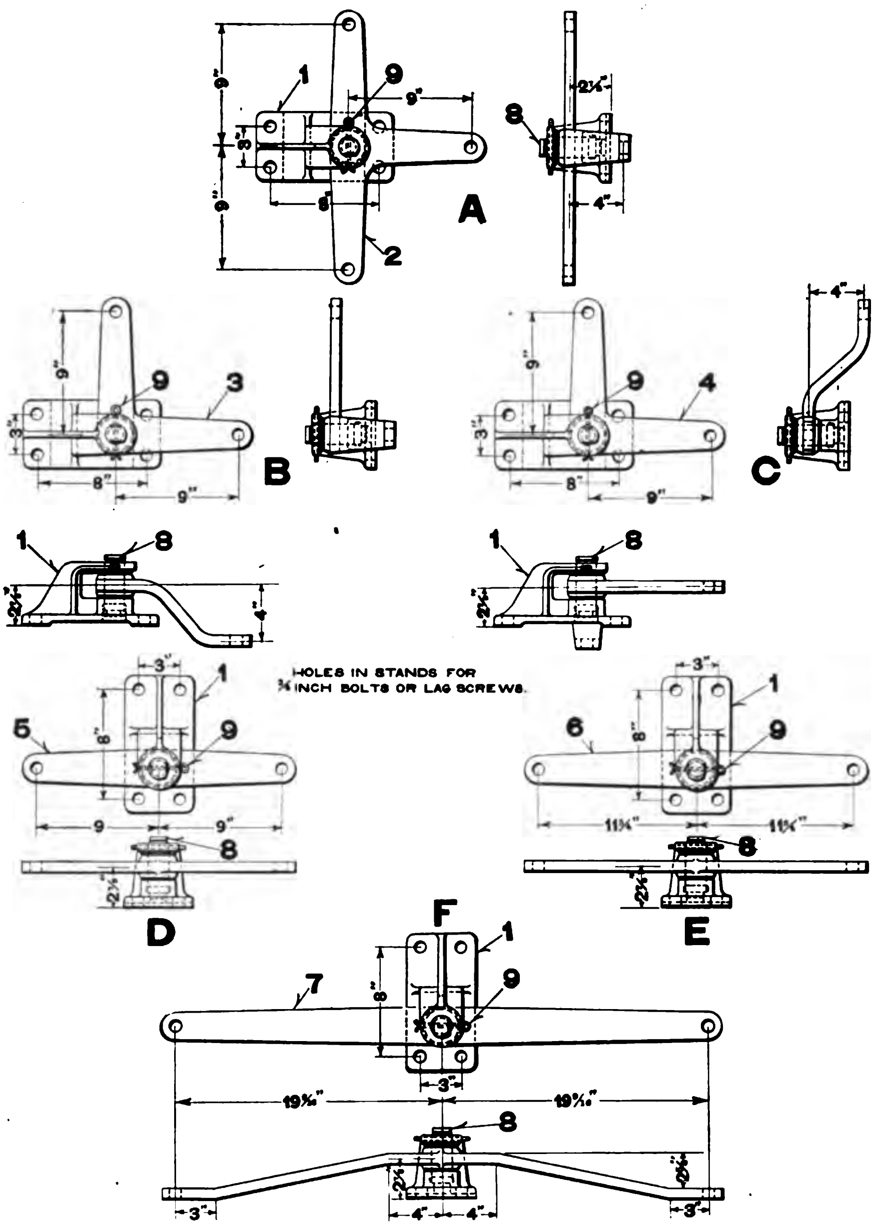
Cranks and compensators are mounted on stands or foundations made of iron legs with wooden tops and bottoms or of concrete (Figs. 1185-1191 and 1198-1201), similar to those used for pipe carriers.

WIRE CONNECTIONS AND COMPENSATION.

Wire is supported and guided by wire carriers (Figs. 1304-1330), mounted on stakes (Figs. 1301-1303 and 1331-1332), or on pipe carrier foundations. Where the direction of the line is changed, ¼ in. proof chain is introduced into the line and led



Figs. 1147-1148. Parallel Compensator. Great Western Railway of England.



Names of Parts. Horizontal One-way Cranks and Stands. Figs. 1149-1162.

A 9" x 9" x 9" *T Crank and Stand*

B 9" x 9" *Crank and Stand*

C 9" x 9" *Crank with 4" Offset and Stand*

D 9" x 9" *Straight Crank and Stand*

E 11¾" x 11¾" *Straight Crank and Stand*

F 19⁹/₁₆" x 19⁹/₁₆" *Straight Crank and Stand*

1 *Stand*

2 9" x 9" x 9" *T Crank*

3 9" x 9" *Crank*

4 9" x 9" *Crank with Offset*

5 9" x 9" *Straight Crank*

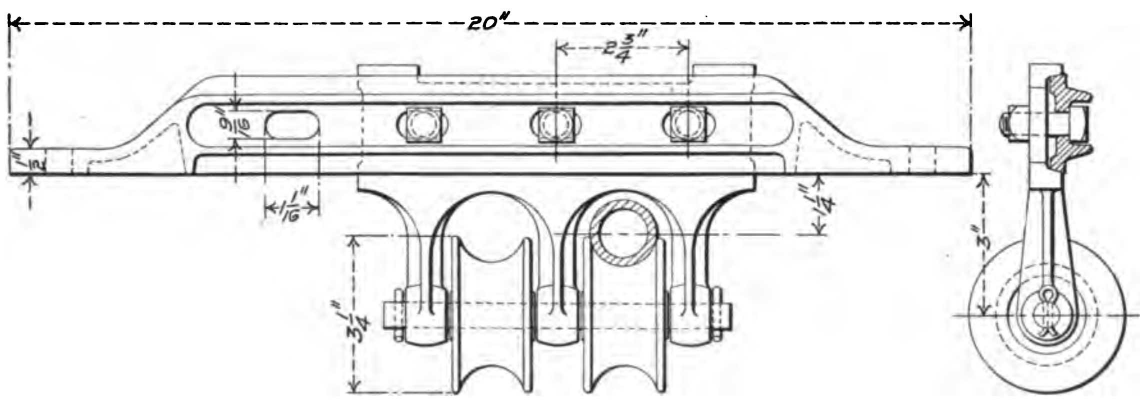
6 11¾" x 11¾" *Straight Crank*

7 19⁹/₁₆" x 19⁹/₁₆" *Straight Crank*

8 *Center Pin*, 1¼"

9 *Cotter*

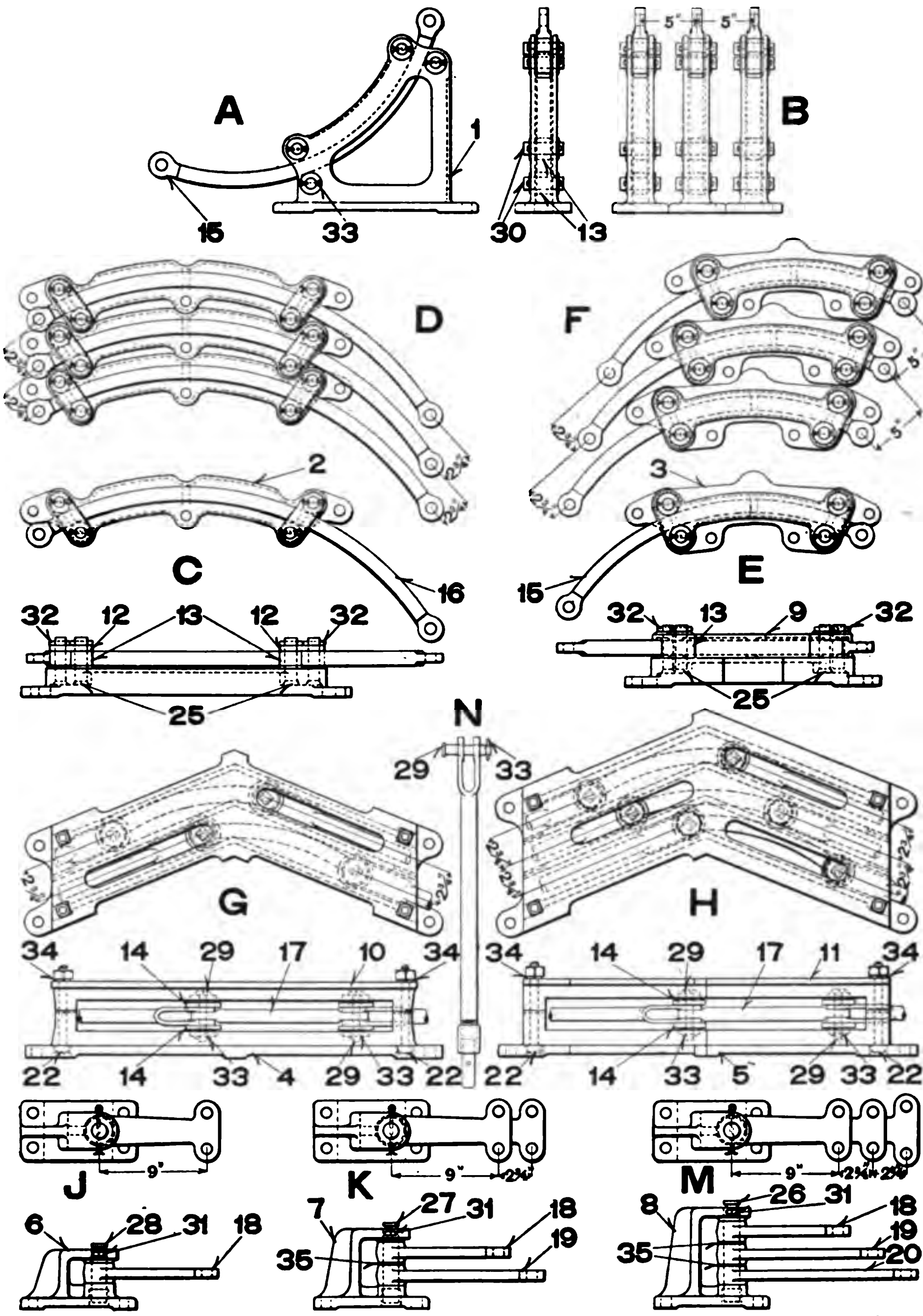
*Figs. 1149-1162. Horizontal Cranks, Straight Arm Compensators and Stands.



Figs. 1163-1164. Details of Transverse Pipe Carrier. New York Central & Hudson River.

around chain wheels (Figs. 1339-1398). These are mounted on foundations like cranks. The chain is fastened to the wire by wire eyes and split links (Figs. 1291-1298).

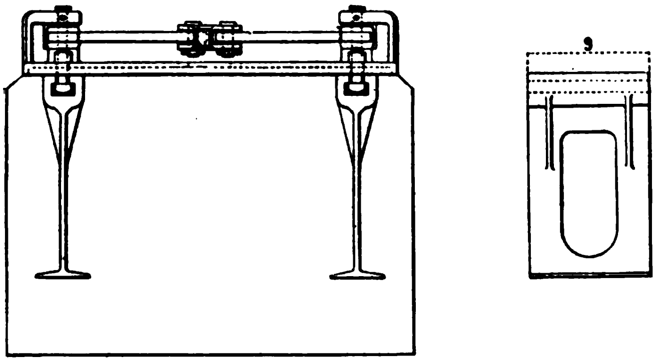
A wire compensator is shown in Figs. 1387-1388. Weight 14 at end of lever 13, which carries chain wheels, takes up all slack in wires and keeps them taut. The weight of 14 is able to overcome that of the spectacle and counterweight 6 when signal is clear. Wires are hooked to the ends of disengaging lever 8 which rests in link 7. This is done instead of connecting direct to balance lever 5, so that should the back wire break, the right hand end of lever 8 will rise through link 7 until the lever assumes a nearly vertical position, when it will allow the pulling wire to slip off



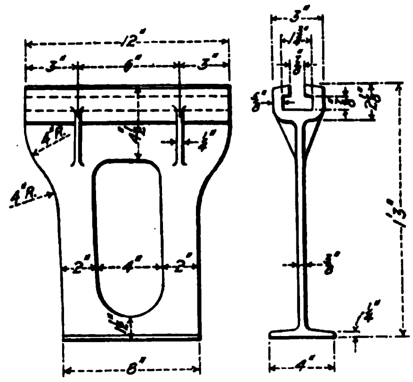
*Figs. 1165-1184. Deflecting Bars and Radial Arms.

Names of Parts, Deflecting Bars and Radial Arms. Figs. 1165-1184.

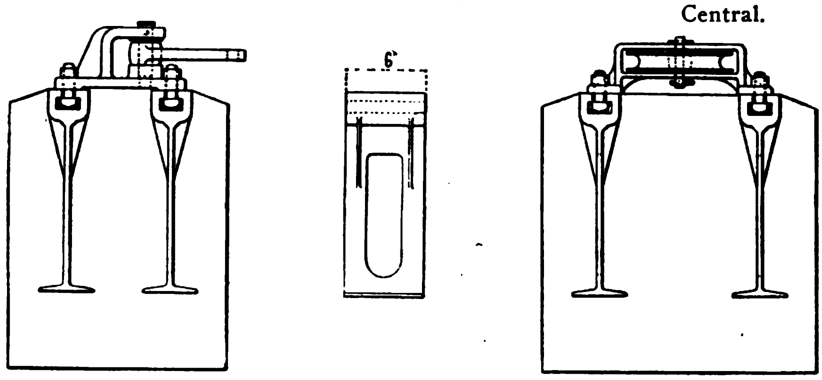
A *Vertical Deflecting Bar*
B *Group of Three Vertical Deflecting Bars*
C *Horizontal Deflecting Bar*
D *Group of Three Horizontal Deflecting Bars*
E *Short Horizontal Deflecting Bar*
F *Group of Three Short Horizontal Deflecting Bars*
G *Deflecting Stand, Two Way*
H *Deflecting Stand, Three Way*
J *Radial Arm and Stand, One Way*
K *Radial Arm and Stand, Two Way*
M *Radial Arm and Stand, Three Way*
N *Wrought Jaw for* **G** *and* **H**
1 *Vertical Deflecting Bar Frame*
2 *Horizontal Deflecting Bar Frame*
3 *Short Horizontal Deflecting Bar Frame*
4 *Deflecting Stand Base, Two Way*
5 *Deflecting Stand Base, Three Way*
6 *Radial Arm Stand, One Way*
7 *Radial Arm Stand, Two Way*
8 *Radial Arm Stand, Three Way*
9 *Cover for Short Deflecting Bar Frame*
10 *Cover for* **G**
11 *Cover for* **H**
12 *Cap for* **2**
13 *Roller*
14 *Washer*
15 *Short Radial Rod*
16 *Long Radial Rod*
17 *Link*
18 *9" Radial Arm*
19 *11¾" Radial Arm*
20 *14½" Radial Arm*
22 *Bolt*
25 *Pin*
26 *Center Pin for* **M**
27 *Center Pin for* **K**
28 *Center Pin for* **J**
29 *Jaw Pin for* **N**
30 *Roller Pin*
31 *Cotter*
32 *Cotter*
33 *Cotter*
34 *Spring Washer*
35 *Spacing Washer*



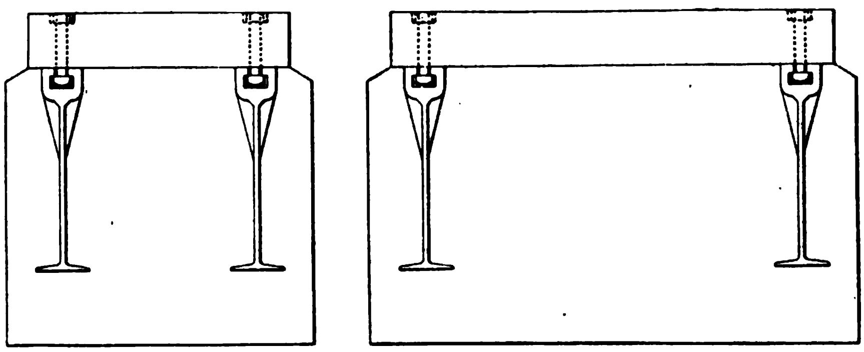
*Figs. 1185-1186. Compensator Foundation; Iron Piers Set in Concrete.



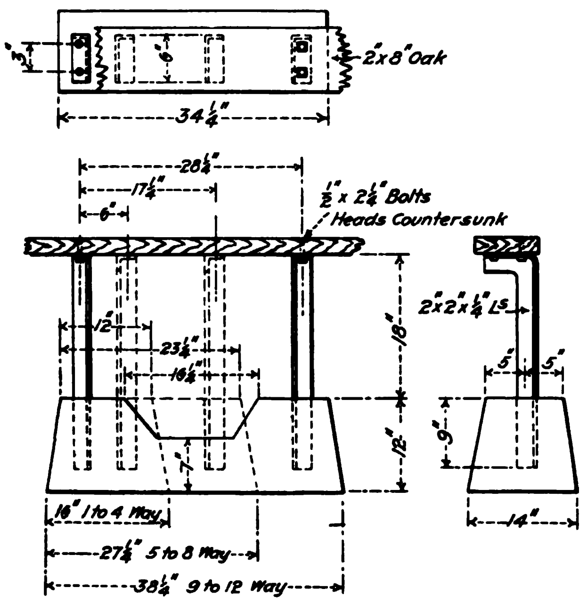
*Figs. 1187-1188. Cast Iron Pier for Concrete Foundation, Illinois Central.



*Figs. 1189-1191. Crank and Chain Wheel Foundations; Iron Piers Set in Concrete.



*Figs. 1192-1193. Pipe Carrier Foundations; Wooden Tops, Bolted to Iron Piers, Set in Concrete.



Figs. 1194-1196. Standard Pipe Carrier Foundation, with Concrete Base. New York, Ontario & Western.

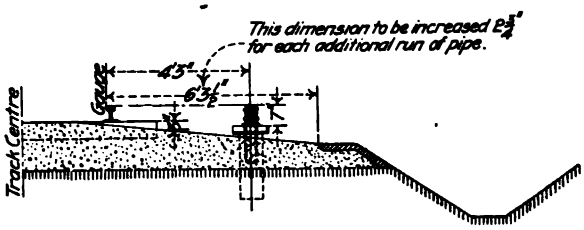
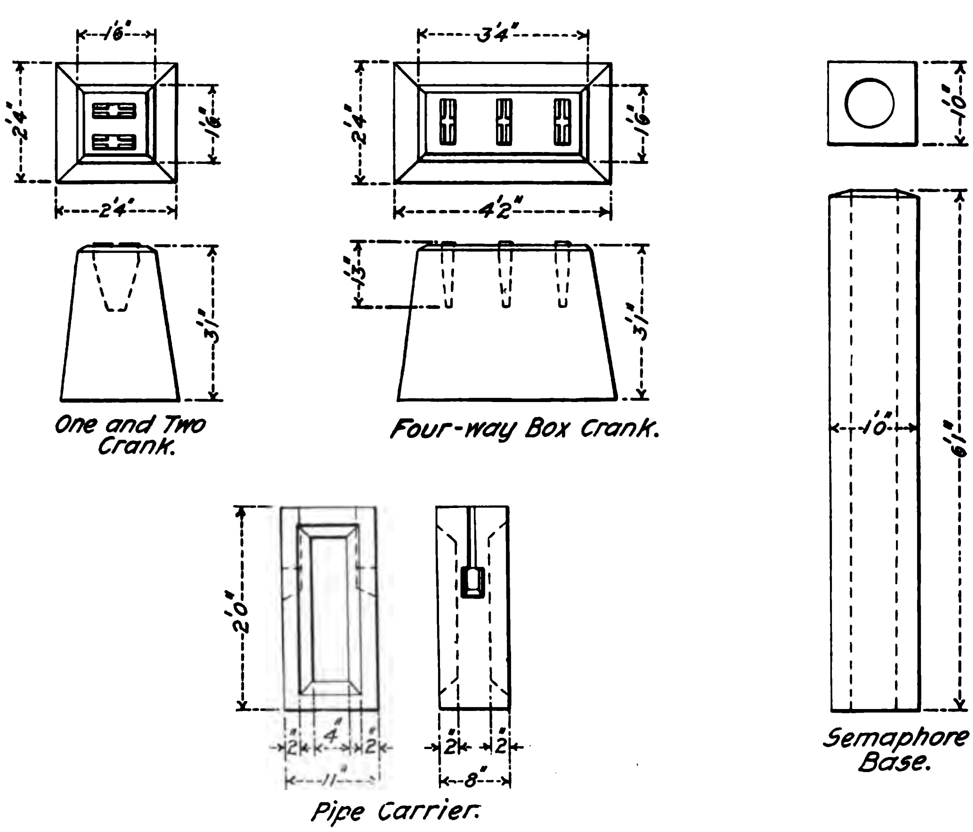
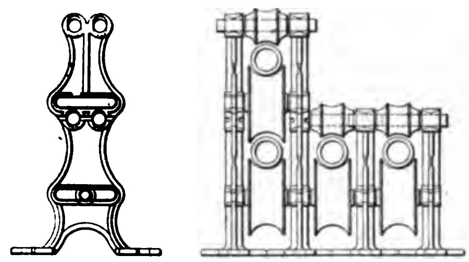


Fig. 1197. Standard Clearance for Pipe Lines. New York Central & Hudson River.

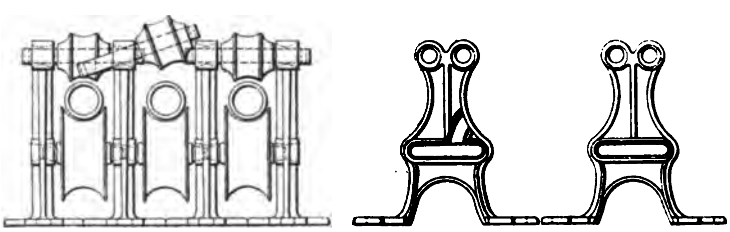


Figs. 1198-1205. Concrete Foundations. Michigan Central.

Fig. 1206. Pipe and Wire Carriers and Concrete Foundations. The Buffalo Railway Supply Company.



Figs. 1207-1208. Double and Single Deck Anti-friction Pipe Carriers. T. George Stiles Company.



Figs. 1209-1211. "Universal" Anti-friction Pipe Carriers. T. George Stiles Company.

of the hook at its left hand end, permitting lever 13 with its weight to drop harmlessly instead of pulling the signal clear.

Figs. 1133-1136 show another type of wire compensator, which is placed at the interlocking machine and is bolted to the machine frame. It consists of a rack and two pinions, each carrying a sprocket wheel mounted in a suitable frame. The rack is connected to the tail lever as shown. At each end of the rack half the teeth are cut away for a short distance, so that in either extreme position only one pinion is engaged. Over each sprocket wheel is hung a sprocket chain D. One end of one chain is connected to the signal pulling wire and one end of the other to the signal back wire. The two sprocket chains are connected together by means of a piece of proof chain E, on which travels a weighted wheel F. The weight H is heavy enough to take up all ordinary slack in the wire but is not heavy enough to pull the signal clear in case the back wire should break. When the apparatus is in the normal position the pinion carrying the back wire sprocket is engaged with the rack. The weight now takes up all slack in the

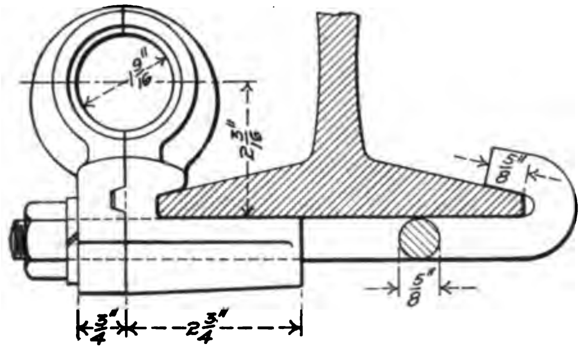
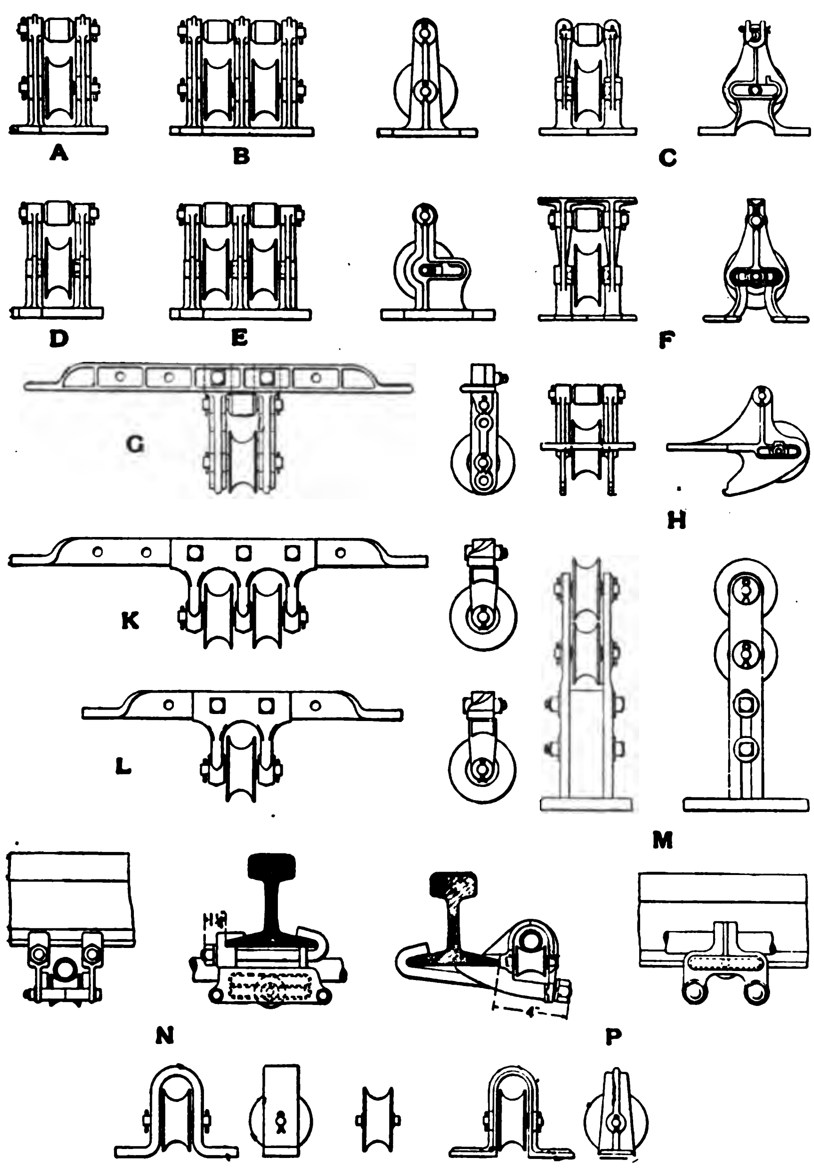


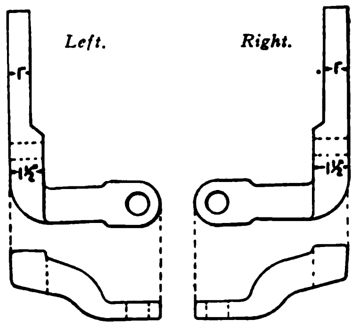
Fig. 1212. Rail Pipe Support. Michigan Central.

Names of Parts; Figs. 1213-1241.

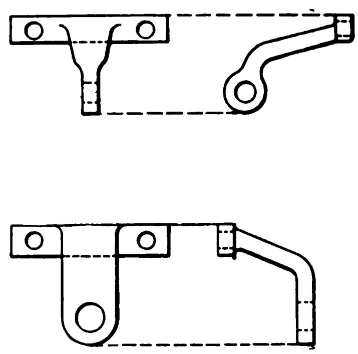
- **A** *One Way Plain Pipe Carrier*
- **B** *Two Way Plain Pipe Carrier*
- **C** *One Way "Universal" Pipe Carrier*
- **D** *One Way Anti-Friction Pipe Carrier*
- **E** *Two Way Anti-Friction Pipe Carrier*
- **F** *One Way "Universal" Pipe Carrier*
- **G** *Transverse Pipe Carrier, One Way*
- **H** *Special One Way Anti-Friction Pipe Carrier for Fastening to Ties*
- **K** *Two Way Transverse Pipe Carrier*
- **L** *One Way Transverse Pipe Carrier*
- **M** *Adjustable Pipe Guide*
- **N** *One Way Rail Clip Transverse Pipe Carrier*
- **P** *Rail Clip Pipe Carrier*
- **Q** *Strap Pipe Carrier*
- **R** *Strap Pipe Carrier*



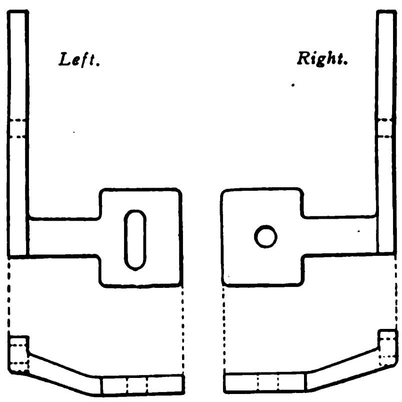
*Figs. 1213-1241. Pipe Carriers.



Figs. 1242-1243.



Figs. 1244-1245.



Figs. 1246-1247.

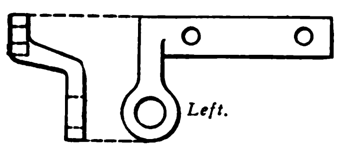


Fig. 1248.

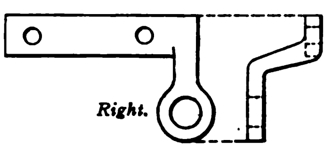


Fig. 1249.

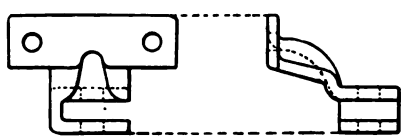
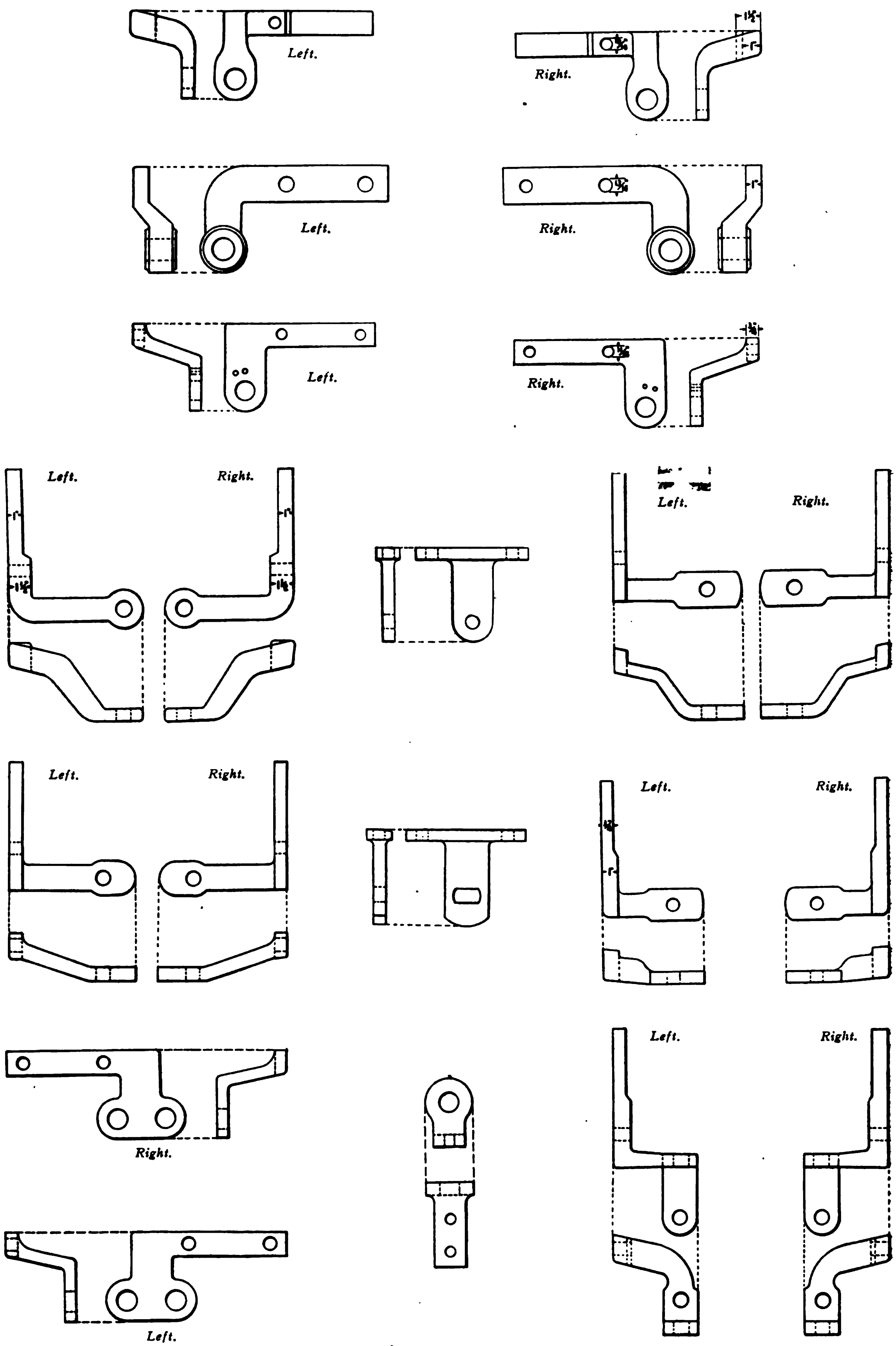


Fig. 1250.

*Figs. 1242-1250. Switch Point Lugs.



*Figs. 1251-1271. Switch Point Lugs.

Fig. 1272. Pipe Lines Crossing Track.

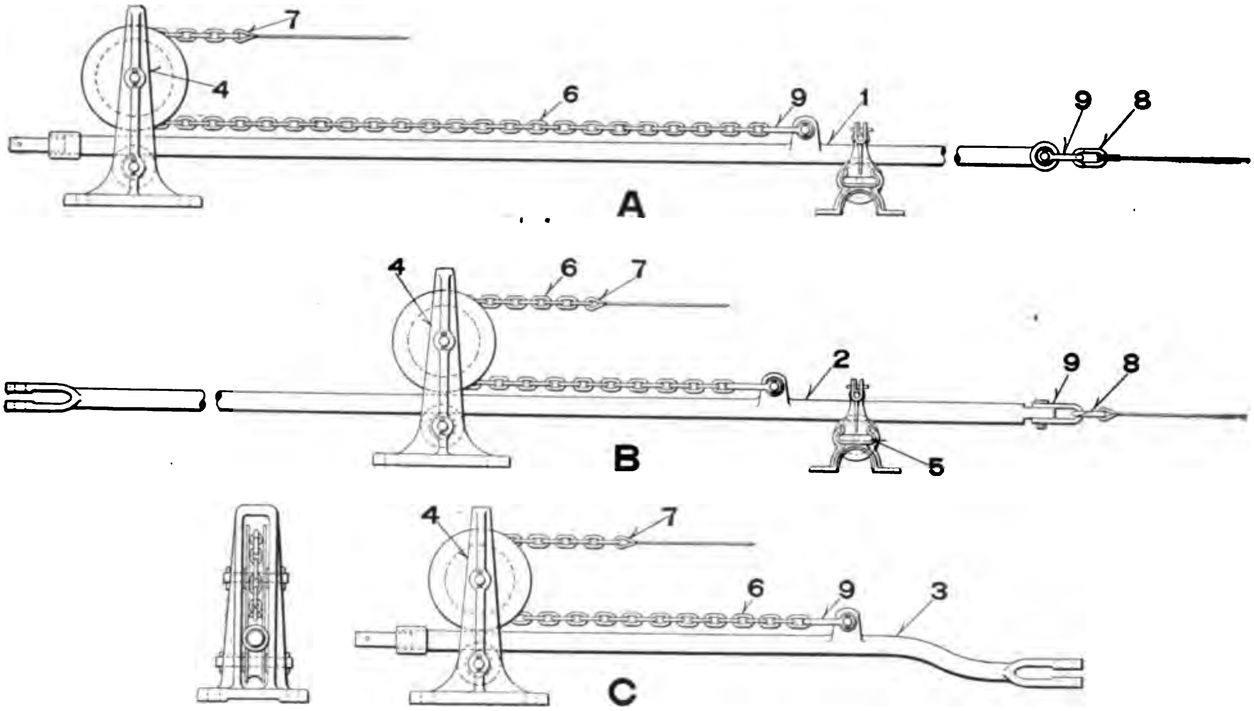
Fig. 1273. Single Wire Stuffing Box.
Railroad Supply Company.

Fig. 1274. Double Wire Stuffing Box.
Railroad Supply Company.

Table of Lengths for Connecting Cranks and Compensators. See Figs. 1282-1284.

Temp. Deg. Fahr.	Lengths of Pipe Line in Feet. 100	150	200	250	300	350	400	450	
120	5/8	15/16	1 1/4	1 5/8	1 15/16	2 1/4	2 9/16	2 7/8	Inches long.
110	9/16	13/16	1 1/8	1 3/8	1 11/16	1 15/16	2 1/4	2 1/2	
100	1/2	3/4	15/16	1 3/16	1 7/16	1 11/16	1 15/16	2 3/16	
90	3/8	5/8	13/16	1	1 3/16	1 3/8	1 5/8	1 13/16	
80	5/16	1/2	5/8	13/16	15/16	1 1/8	1 1/4	1 7/16	
70	1/4	3/8	1/2	5/8	3/4	13/16	15/16	1 1/16	
60	3/16	1/4	5/16	3/8	1/2	9/16	5/8	3/4	
50	1/16	1/8	3/16	3/16	1/4	1/4	5/16	3/8	
40				Mean					
30	1/16	1/8	3/16	3/16	1/4	1/4	5/16	3/8	Inches short.
20	3/16	1/4	5/16	3/8	1/2	9/16	5/8	3/4	
10	1/4	3/8	1/2	5/8	3/4	13/16	15/16	1 1/16	
0	5/16	1/2	5/8	13/16	15/16	1 1/8	1 1/4	1 7/16	
—10	3/8	5/8	13/16	1	1 3/16	1 3/8	1 5/8	1 13/16	
—20	1/2	3/4	15/16	1 3/16	1 7/16	1 11/16	1 15/16	2 3/16	
—30	9/16	13/16	1 1/8	1 3/8	1 11/16	1 13/16	2 1/4	2 1/4	
—40	5/8	15/16	1 1/4	1 5/8	1 15/16	2 1/4	2 9/16	2 1/8	

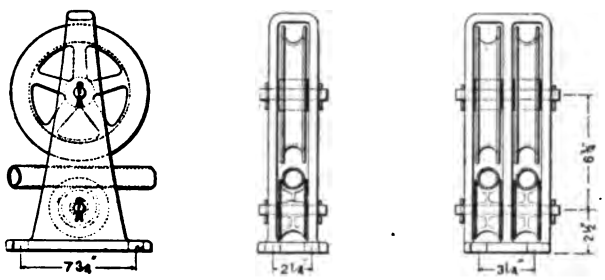
NOTE.—The figures in this table are approximately correct. The basis is .008" on every 100' for 1° F. variation in temperature.



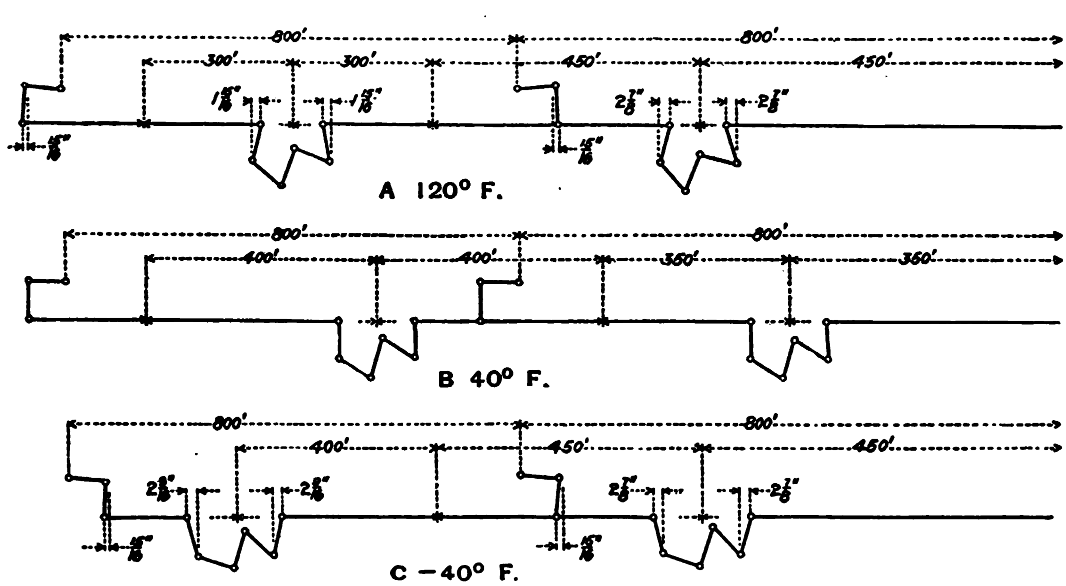
*Figs. 1275-1278. Special Lugs and Attachments for Changing from Pipe to Wire Connections.

Names of Parts, Special Lugs and Attachments, for Changing from Pipe to Wire; Figs. 1275-1278.

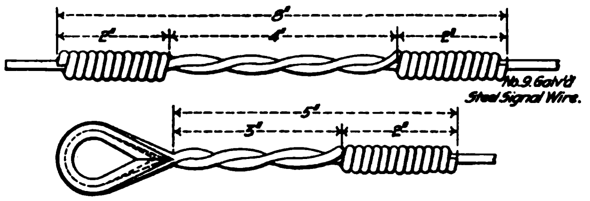
A	*With Tang End Rod*	4	*One-Way Special Wheel*
B	*With Jaw*	5	*Pipe Carrier*
C	*With Jaw and Tang End; One Wire*	6	*Chain*
1	*Lug with Tang End and Eye*	7	*Wire Eye*
2	*Lug with Jaw and Eye*	8	*Split Link*
3	*Lug with Tang End and Jaw*	9	*Shackle*



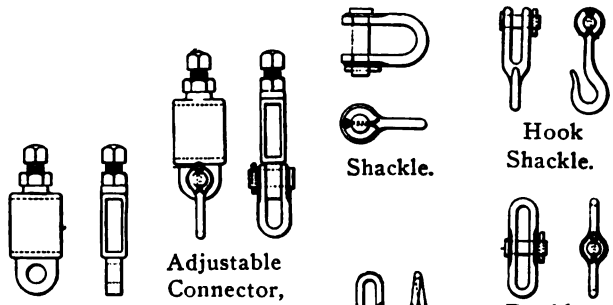
*Figs. 1279-1281. Wheels for Changing from Pipe to Wire. See Figs. 1275-1278.



Figs. 1282-1284. Diagrams Showing Effects of Temperature Changes on Cranks and Compensators in Pipe Lines. (See Table on Opposite Page.)

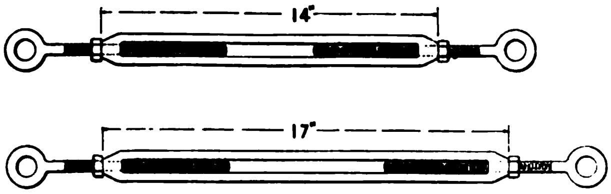


Figs. 1285-1286. Splice and Method of Attaching Wire Eye to Wire. New York Central.

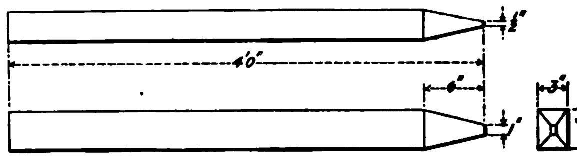


Adjustable Connector. Adjustable Connector, with Shackle. Shackle. Split Link. Hook Shackle. Double Shackle.

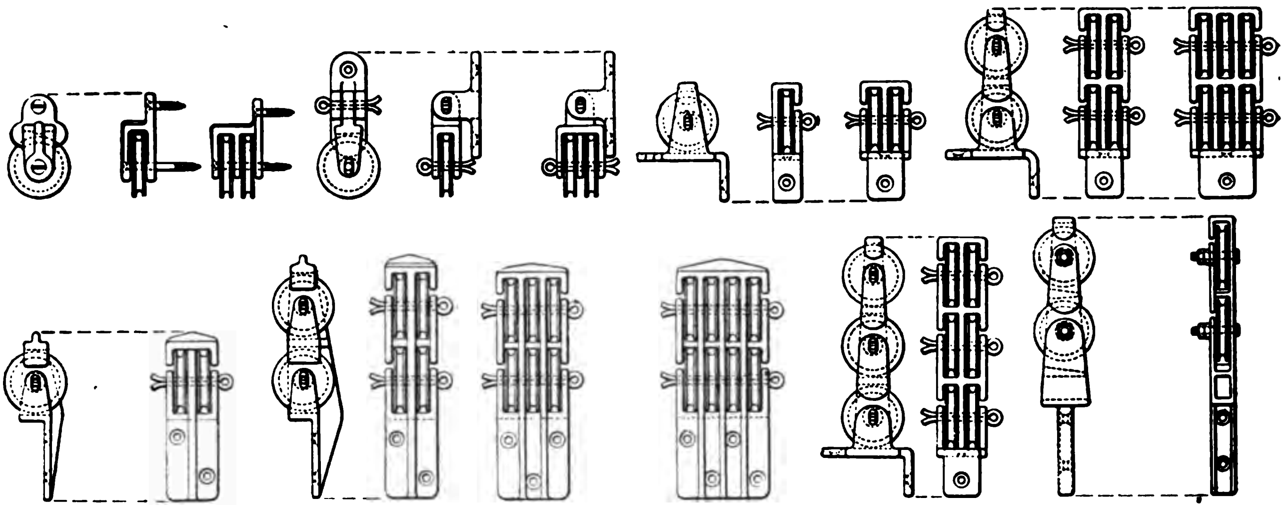
*Figs. 1287-1298.

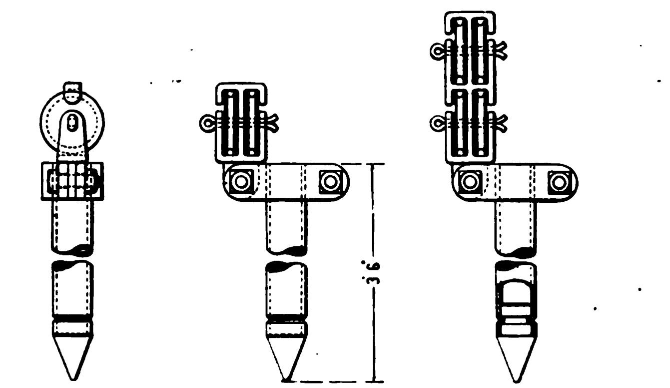


*Figs. 1299-1300. Wire Adjusting Screws.

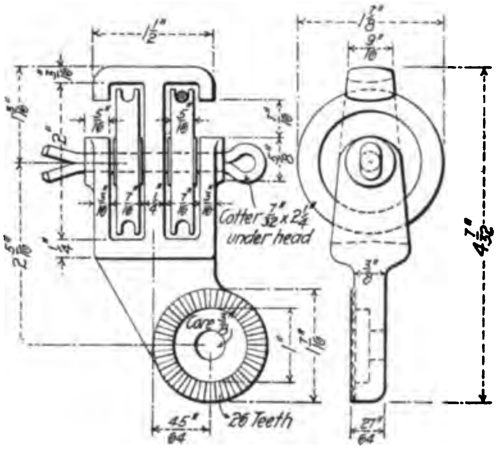


*Figs. 1301-1303. Wooden Stake for Wire Carriers.

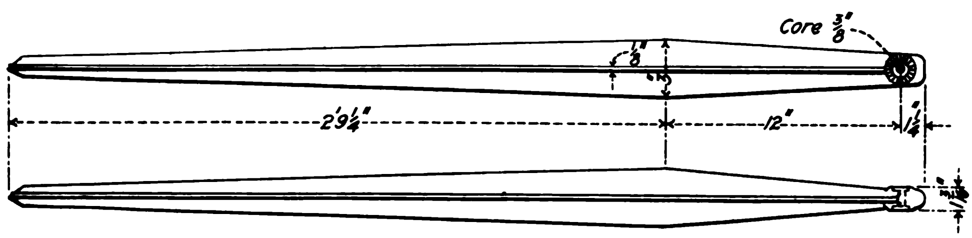




*Figs. 1304-1328. Wire Carriers.



Figs. 1329-1330.

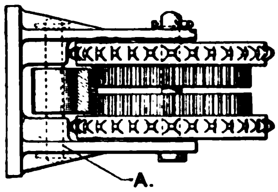


Figs. 1331-1332.

Figs. 1329-1332. Two-Way Adjustable Wire Carrier and Cast Iron Stake. Buffalo Railway Supply Company.

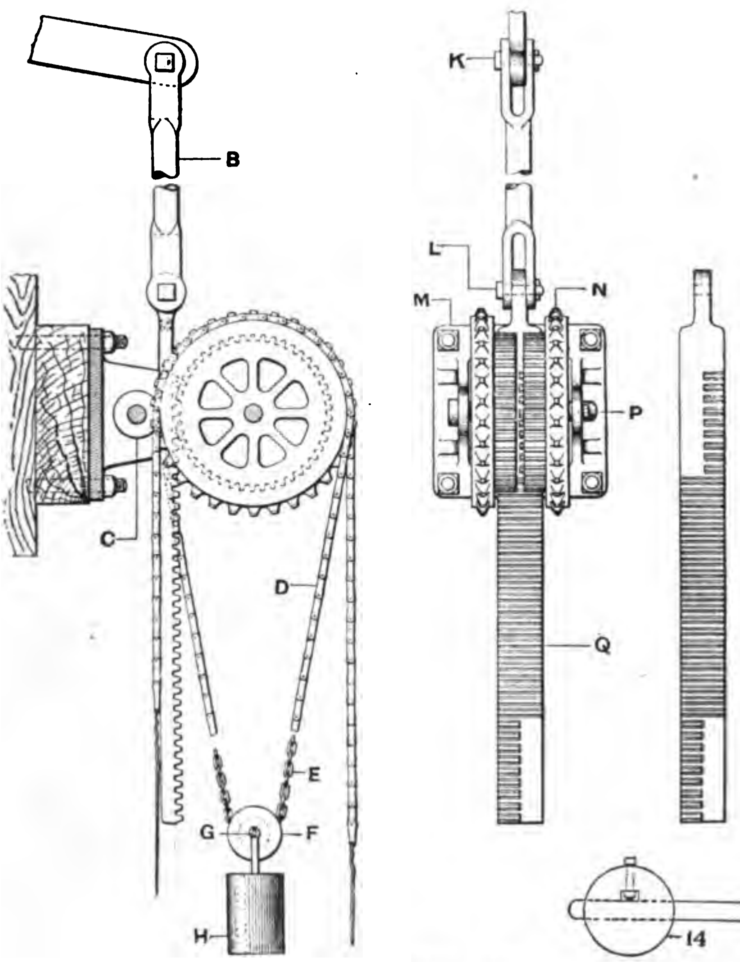
Names of Parts of Wire Compensator; Figs. 1333-1336.

A *Pin*	**F** *Wheel*	**M** *Stand*
B *Connecting Rod*	**G** *Pin*	**N** *Sprocket Wheel*
C *Roller*	**H** *Weight*	**P** *Pin*
D *Sprocket Chain*	**K** *Pin*	**Q** *Rack*
E *Proof Chain*	**L** *Pin*	

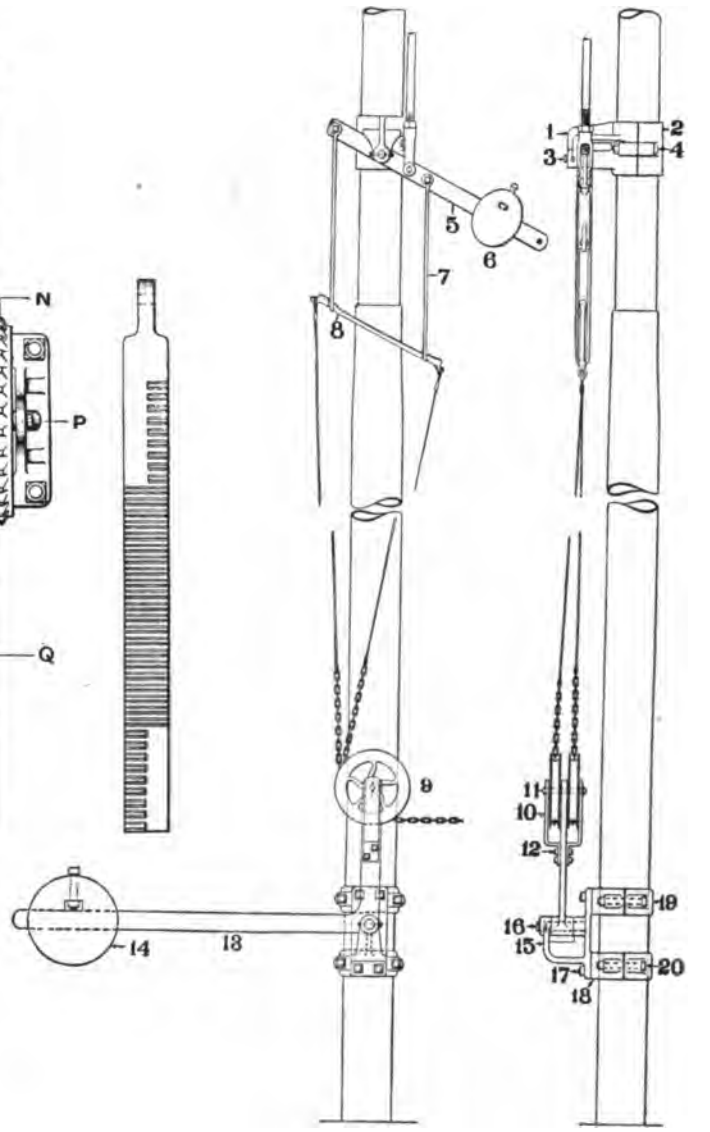


Names of Parts of Wire Compensator; Figs. 1337-1338.

1 *Balance Lever Bracket*	**8** *Disengaging Lever*	**14** *Compensator Counterweight*
2 *Half-Clamp*	**9** *Chain Wheels*	**15** *Compensator Lever Bracket*
3 *Pin*	**10** *Side Bracket*	**16** *Pin*
4 *Bolt*	**11** *Chain Wheel Pin*	**17** *Bolt*
5 *Balance Lever*	**12** *Bolts*	**18** *Front Half of Clamp*
6 *Counterweight*	**13** *Compensator Lever*	**19** *Back Half of Clamp*
7 *Link*		**20** *Clamp Bolt*



Figs. 1333-1336. Wire Compensator. The General Railway Signal Company.



*Figs. 1337-1338. Wire Compensator.

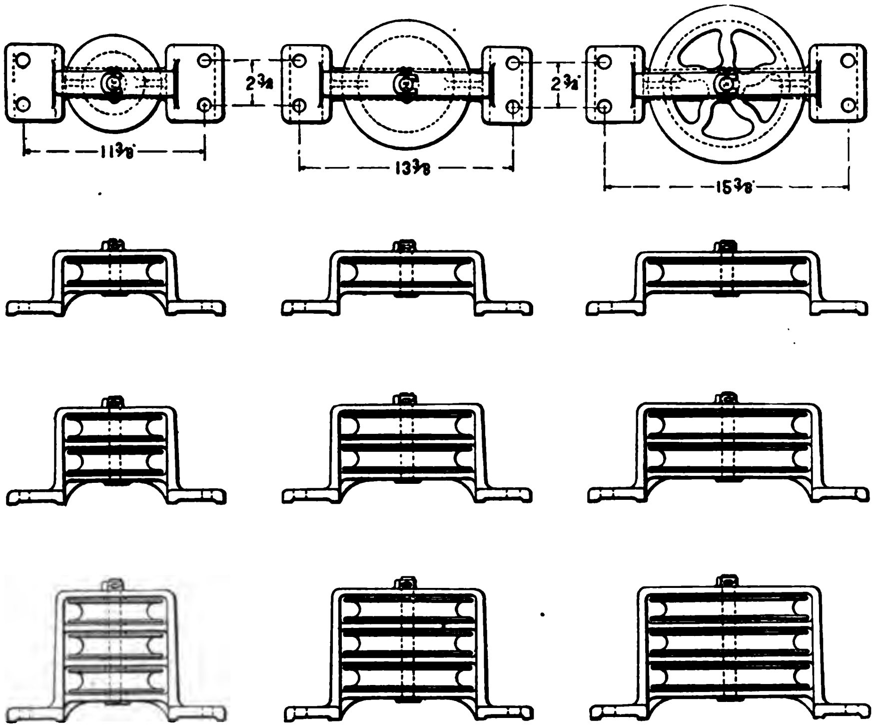
pulling wire. Movement of the lever brings the rack into engagement with the other pinion also, and clears the signal. When in the full reverse position the back wire sprocket pinion is disengaged and the weight takes up all slack in the back wire. When the wires contract the reverse action takes place, the weight of H being such that it will be lifted if a wire is too tight.

Figs. 1477-1478 illustrate a method by which a single wire signal may be adjusted by the signalman to changes in temperature.

BOLT LOCKS.

It is customary to bolt look all high speed signals with facing point switches in the route governed, so that should the switch be set wrong or be partially open, on account of broken switch or facing point lock connections, the signal could not be cleared. A bolt lock (Figs. 1451-1470) consists of two notched bars working at right angles to each other in a frame. One rod is connected to the switch point and the other forms part of the line to the signal. The notches are so arranged that unless the switch is set right the signal bar cannot move, and after the signal has been cleared its bar locks the switch bar so that the switch cannot be moved until the signal has been restored to the normal position.

An English device, known as a "point detector and restorer," is shown in Figs. 1471-1473. It is essentially a bolt lock for use with wire connected signals when only one wire is used. E is the bar attached to the switch point, having a notch and interlocking with notched bar C as in American practice. C is connected in the signal line. Bar A is operated by the pipe line for the facing point lock. Block D is set into a notch in bar C, and block B



*Figs. 1339-1350. One, Two and Three Way Horizontal Chain Wheels.

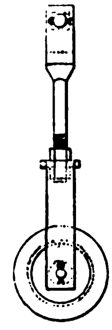


Fig.1351.

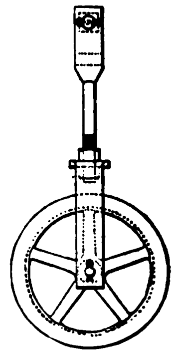
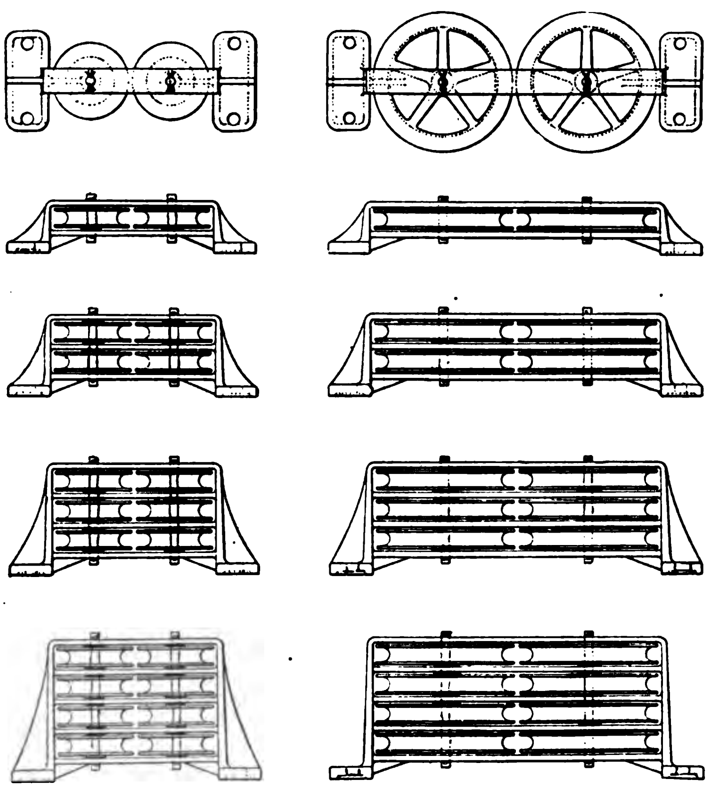
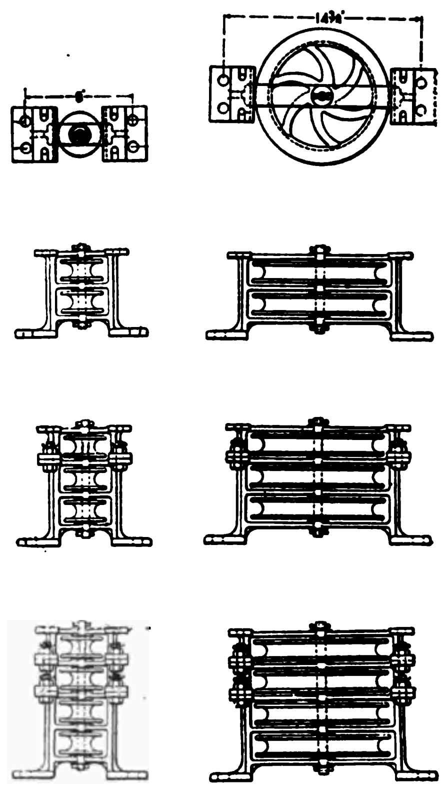


Fig. 1352.

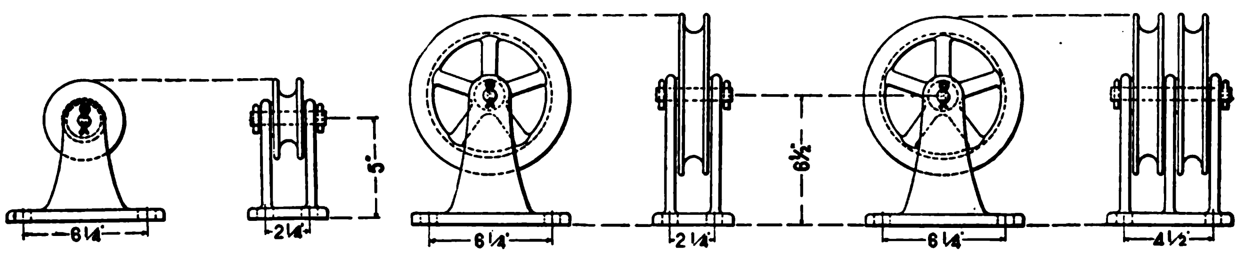
*Figs. 1351-1352. Gain Stroke Chain Wheels.



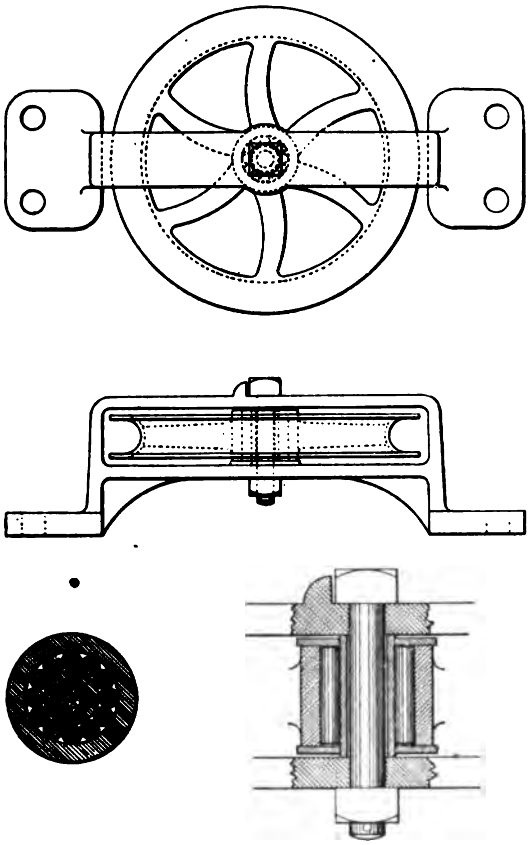
*Figs. 1353-1362. Types of Tandem Horizontal Chain Wheels.



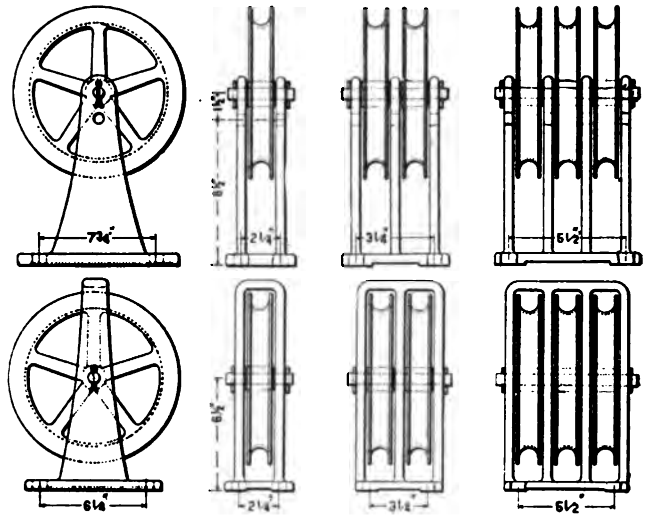
*Figs. 1363-1370. Multiple Horizontal Chain Wheels.



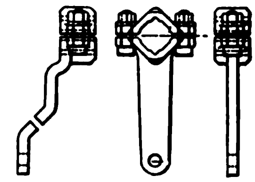
*Figs. 1371-1376. Types of Vertical Chain Wheels.



*Figs. 1377-1380. Roller Bearing Horizontal Chain Wheel.



*Figs. 1381-1388. Types of Vertical Chain Wheels.



*Figs. 1399-1401. Arms for Square Rocker Shafts.

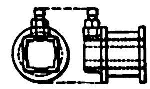
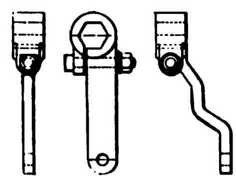
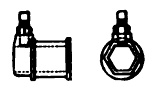


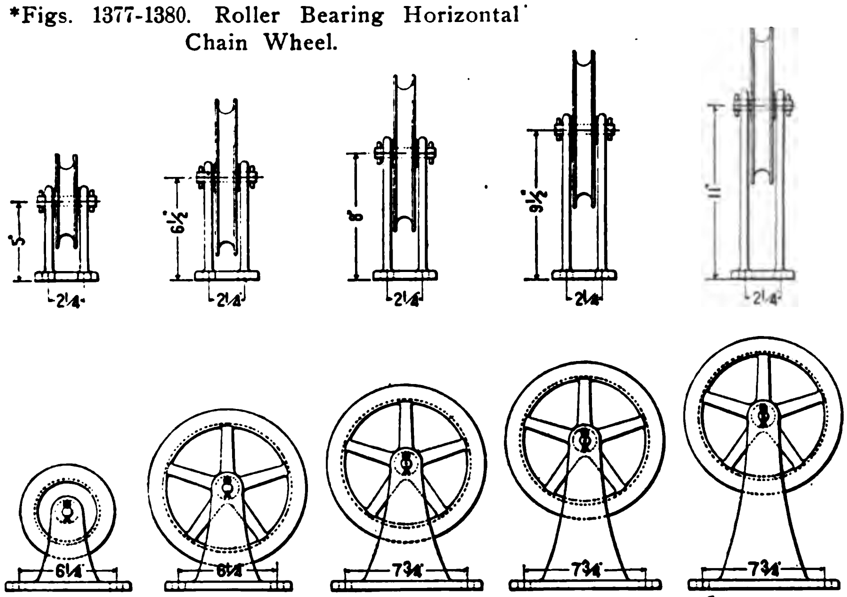
*Fig. 1402. Journal for Square Rocker Shafts.



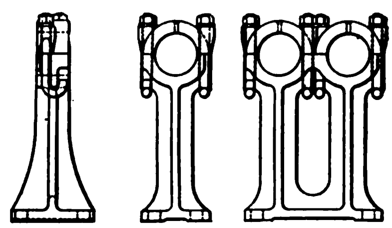
*Figs. 1403-1405. Arms for Hexagonal Rocker Shafts.



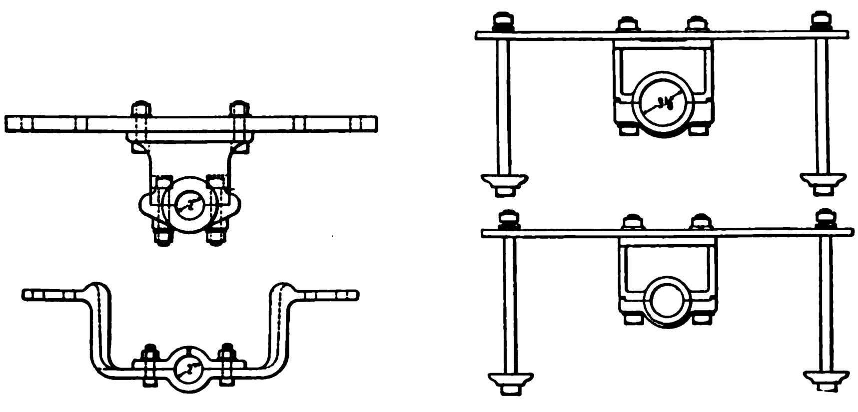
*Figs. 1406-1407. Journal for Hexagonal Rocker Shafts.



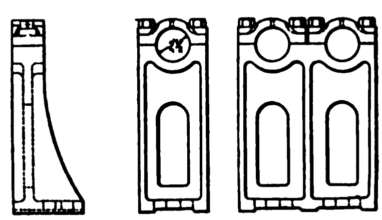
*Figs. 1389-1398. Types of Single Vertical Chain Wheels.



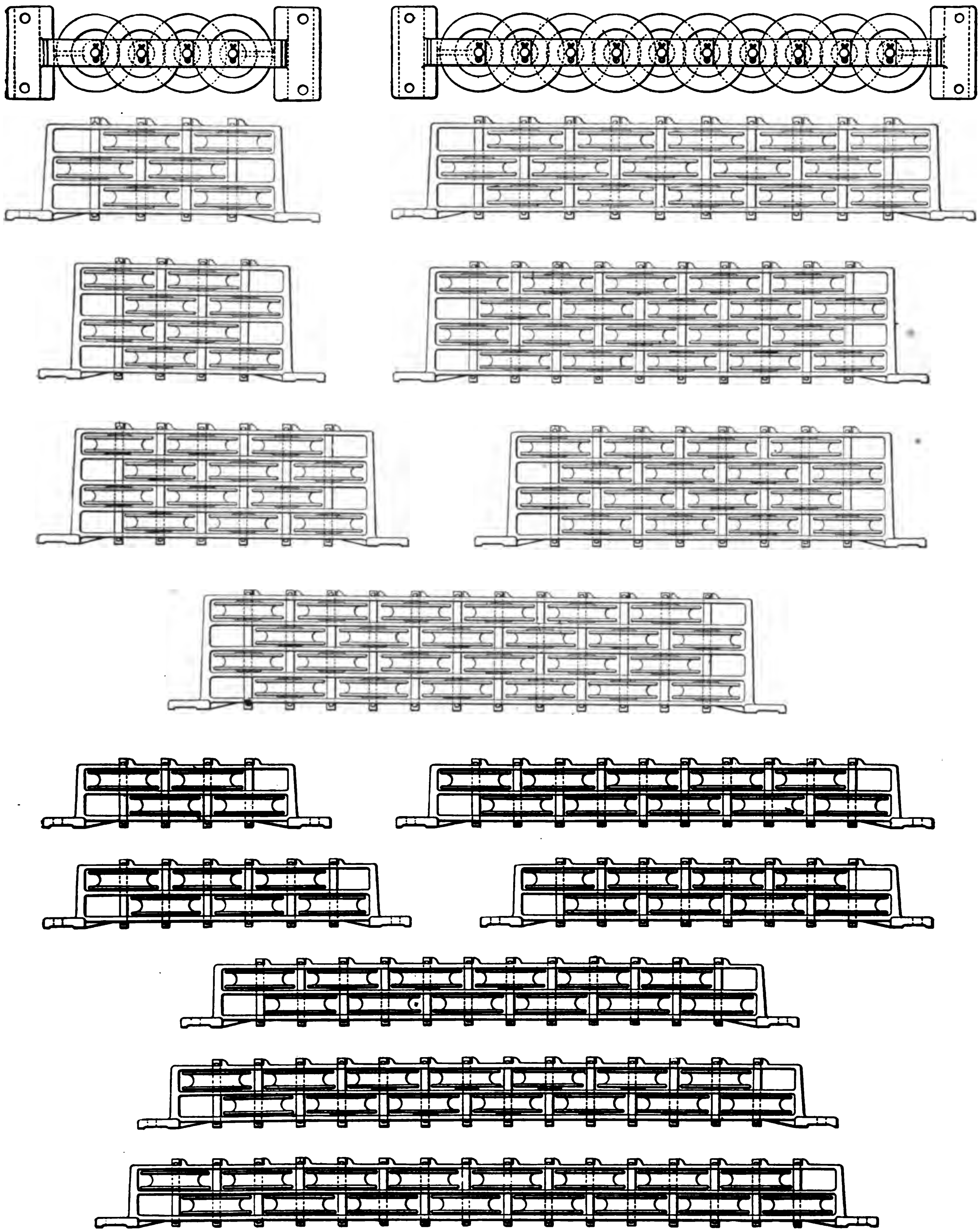
*Figs. 1411-1413. Rocker Shaft Bearings for Square Rocker Shafts.



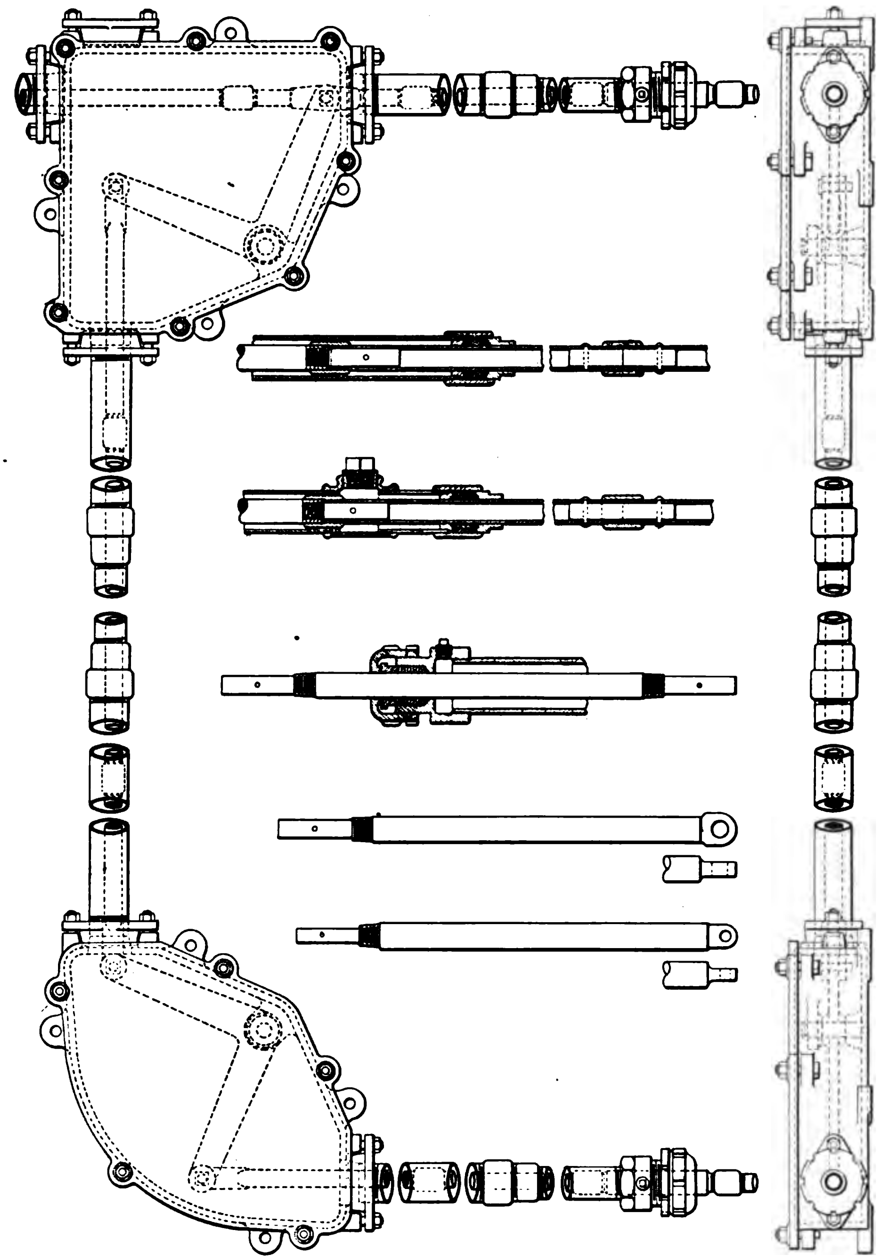
*Figs. 1408-1410. Rocker Shaft Bearing for Use Between Ties.



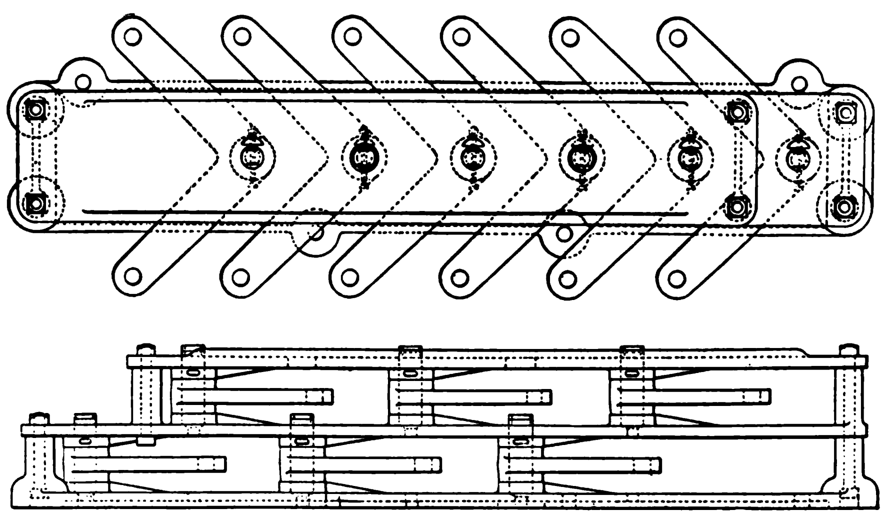
*Figs. 1414-1416. Rocker Shaft Stands.



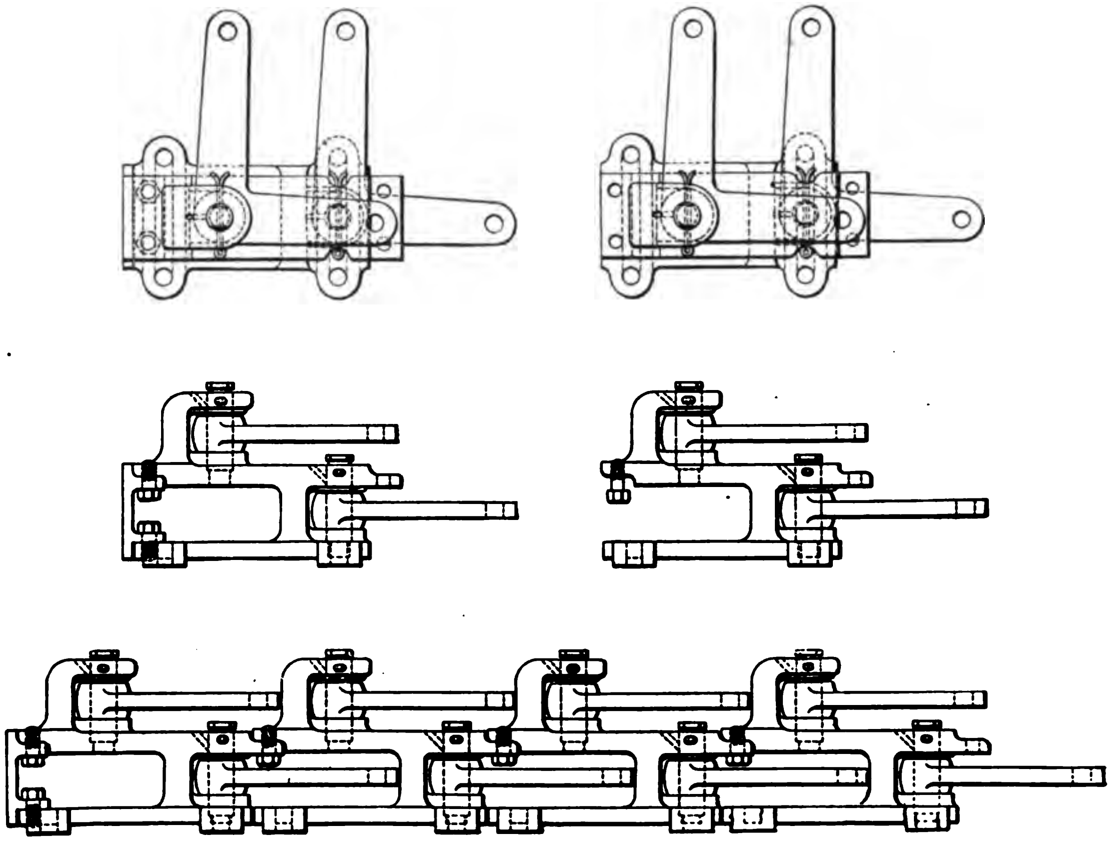
*Figs. 1417-1432. Types of Box Wheels.



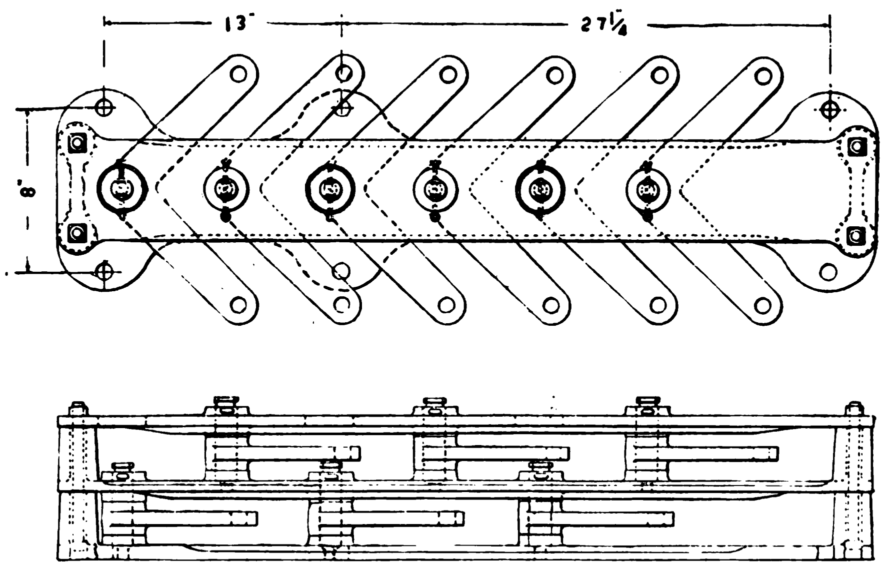
Figs. 1433-1441. Oil Crank Boxes, Oil Pipe, Stuffing Boxes and Plungers.



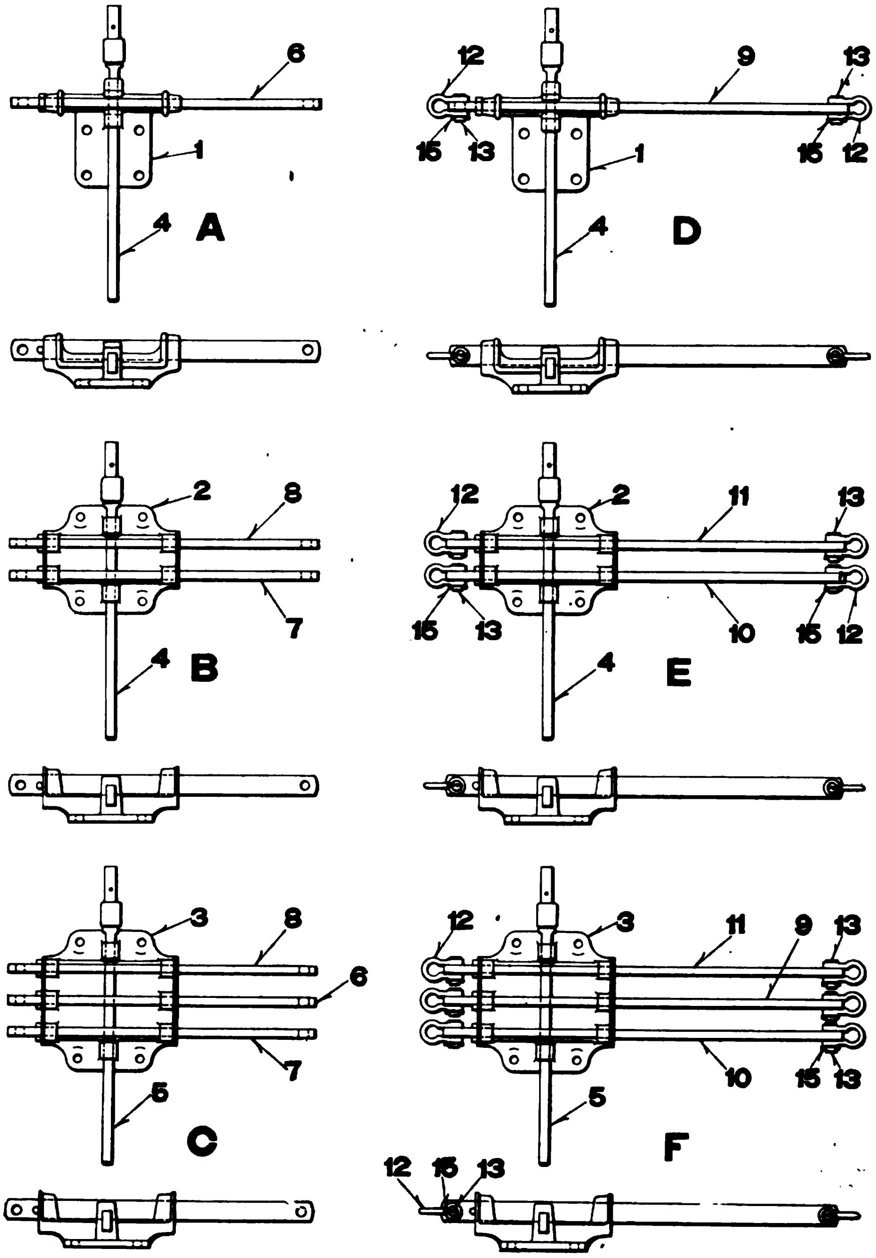
*Figs. 1442-1443. Box Crank, Cotters Below Frame.



*Figs. 1444-1448. Separate Pin Leadout Cranks.



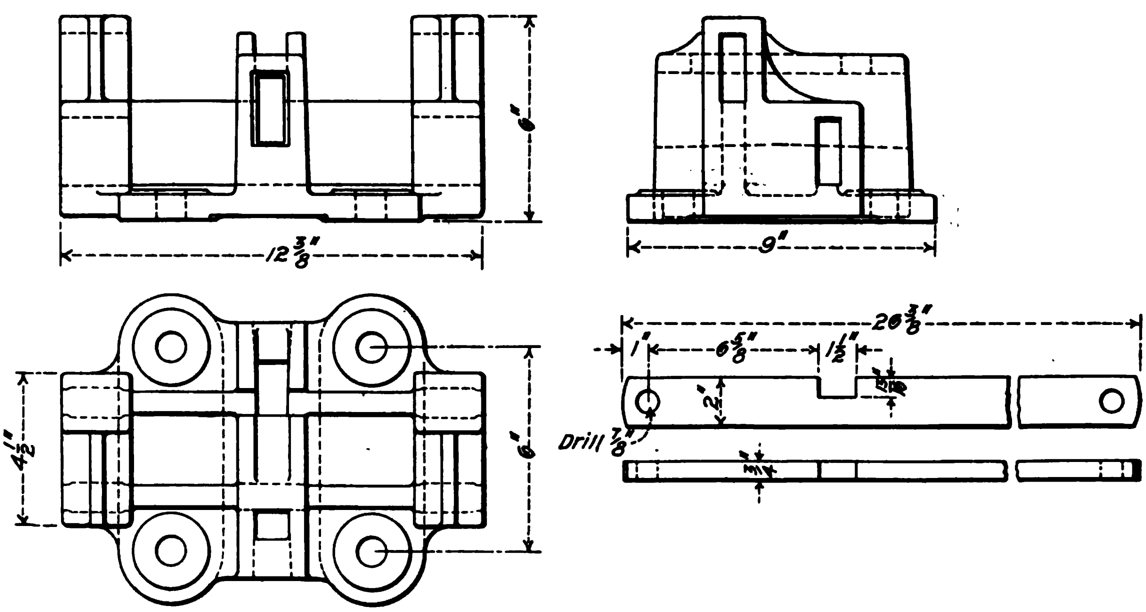
*Figs. 1449-1450. Box Crank, Cotters Above Frame.



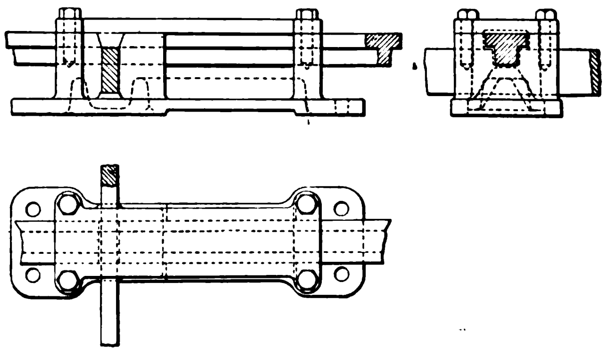
*Figs. 1451-1462. Bolt Locks.

Names of Parts, Bolt Locks; Figs. 1451-1462.

- A *One-Way Bolt Lock, Pipe Connected*
- B *Two-Way Bolt Lock, Pipe Connected*
- C *Three-Way Bolt Lock, Pipe Connected*
- D *One-Way Bolt Lock, Wire Connected*
- E *Two-Way Bolt Lock, Wire Connected*
- F *Three-Way Bolt Lock, Wire Connected*
- 1 *One-Way Stand*
- 2 *Two-Way Stand*
- 3 *Three-Way Stand*
- 4 *Switch-Bar for One or Two-Way Stand*
- 5 *Switch-Bar for Three-Way Stand*
- 6 *Signal-Bar for Pipe Connection*
- 7 *Signal-Bar for Pipe Connection, Right-Hand Beveled*
- 8 *Signal-Bar for Pipe Connection, Left-Hand Beveled*
- 9 *Signal-Bar for Wire Connection*
- 10 *Signal-Bar for Wire Connection, Right-Hand Beveled*
- 11 *Signal-Bar for Wire Connection, Left-Hand Beveled*
- 12 *Shackle*
- 13 *Pin*
- 15 *Cotter*



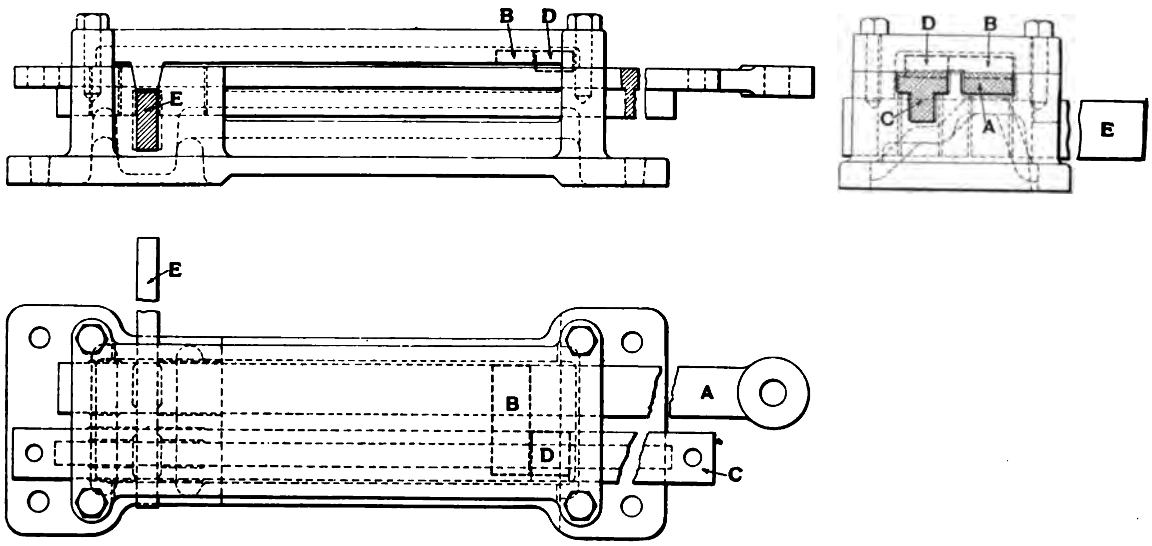
Figs. 1463-1467. Two-Way Bolt Lock Details. Michigan Central.



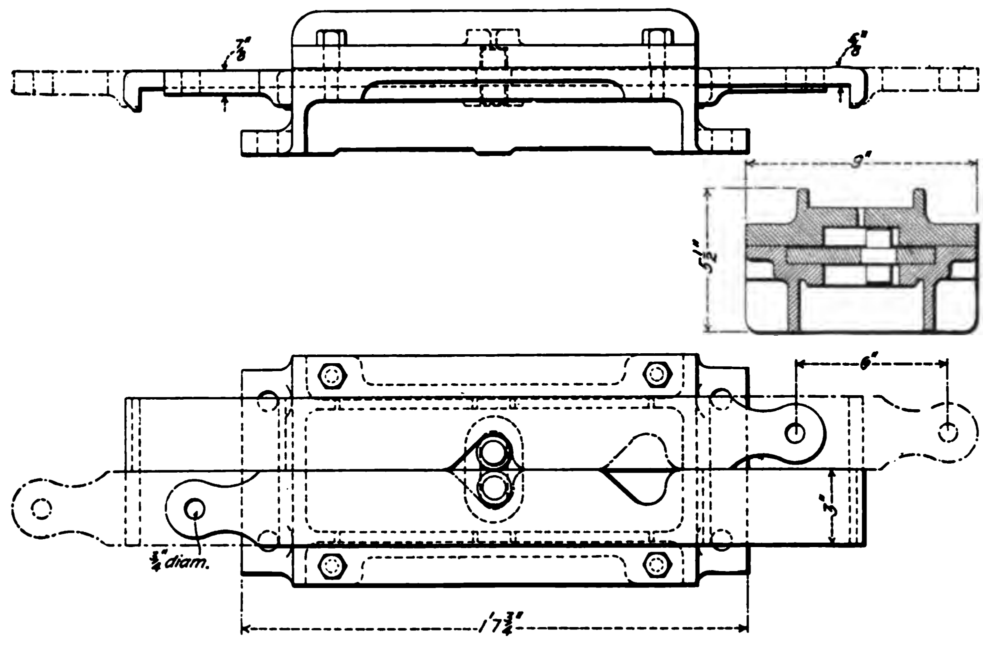
Figs. 1468-1470. Point Detector or Bolt Lock. Great Western Railway of England.

Names of Parts, Point Detector and Restorer; Figs. 1471-1473.

A *Facing Point Lock Bar*
B *Block in* **A**
C *Signal Bar*
D *Block in* **C**
E *Switch Bar*



Figs. 1471-1473. Point Detector and Restorer. Great Western Railway of England.

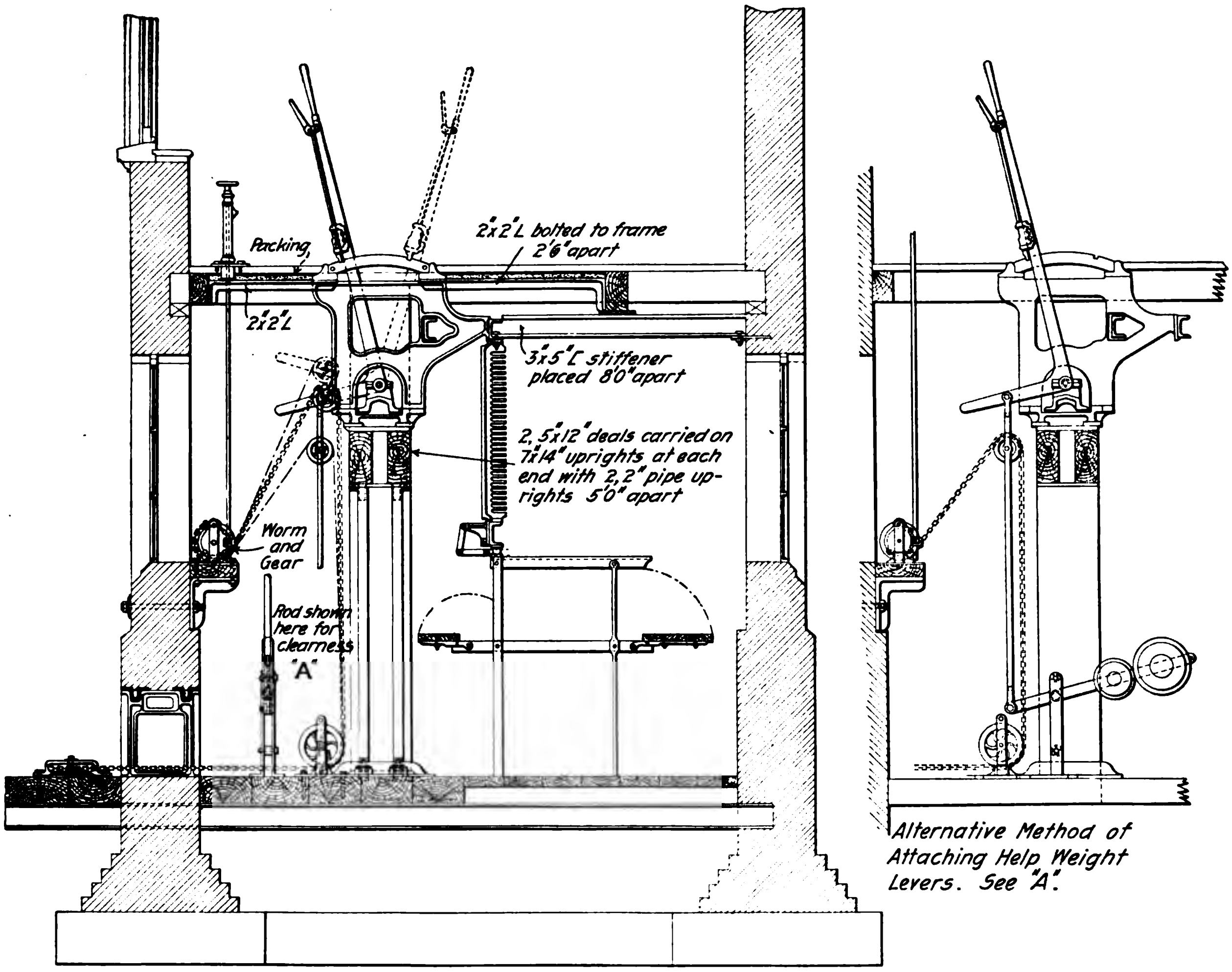


Figs. 1474-1476. Ground Lock. Great Western of England.

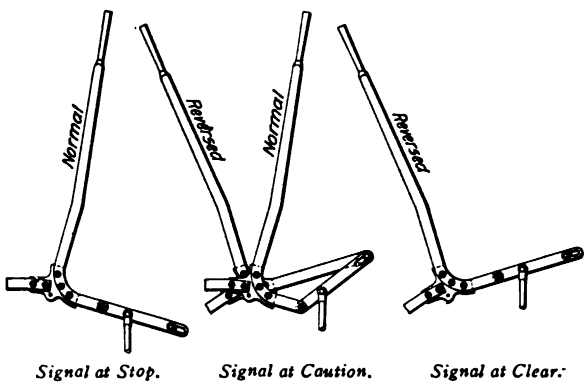
into a notch in bar A. When the switch is locked bar A is pushed in, carrying block B with it. The signal can then be cleared. If, when the signal lever is put normal, the bar C should not make sufficient stroke to release E, the block B would strike against block D when the switch was unlocked, thus forcing C through the remainder of its stroke and releasing E. This device therefore automatically overcomes the effects of contraction between the lever and the bolt lock, and of slack wire between the bolt lock and the signal.

SELECTED SIGNALS.

Several signals may be operated from one lever by means of selectors, the signal cleared depending upon the position of the various switches. Figs. 1482-1483 show a perspective view of a



Figs. 1477-1478. Single Wire Compensator and Leadout Arrangements. Great Western of England.



Figs. 1479-1481. Method of Operating a Three-Position Signal from Two Levers. Baltimore & Ohio.

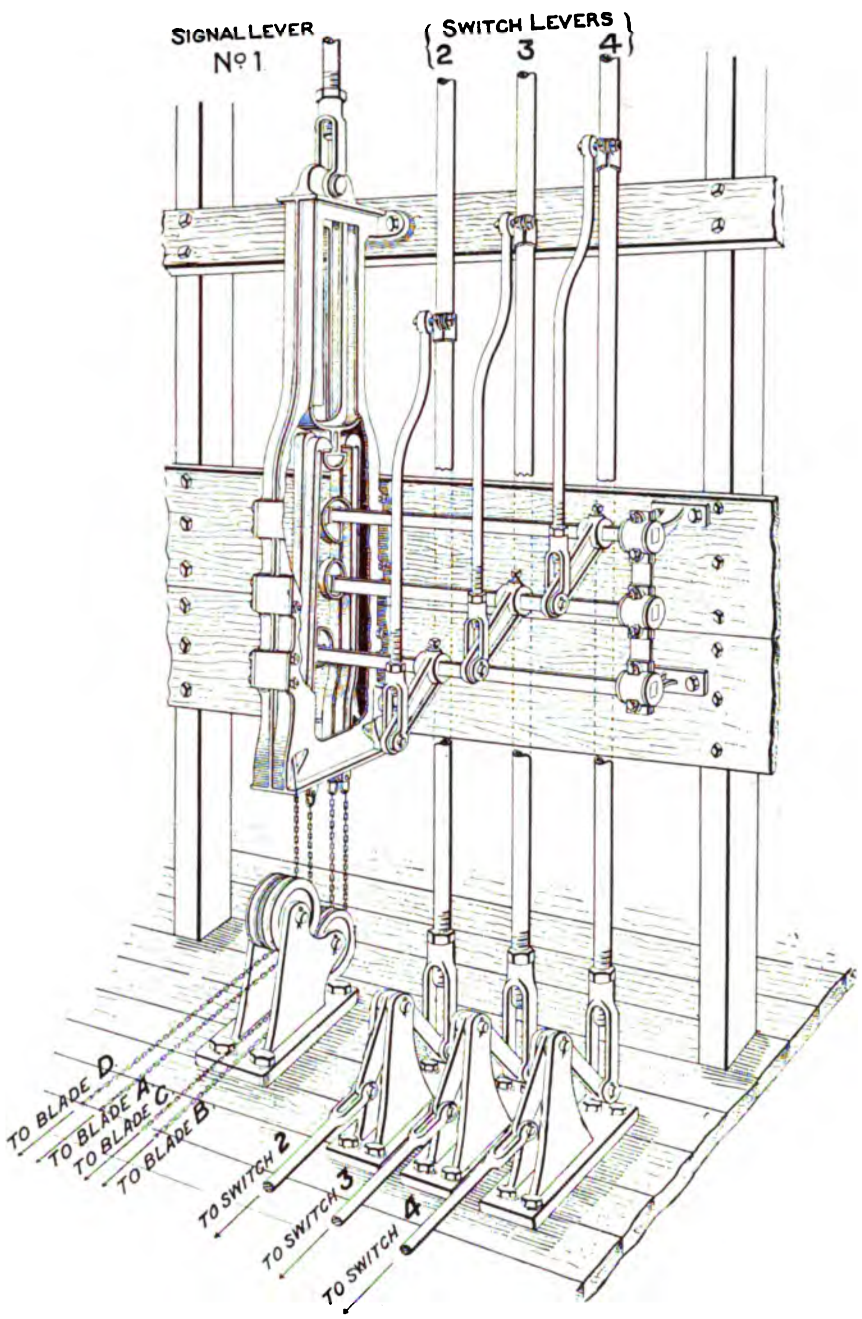


Fig. 1482. Wire Connected Cabin Hook Selector. The Union Switch & Signal Company.

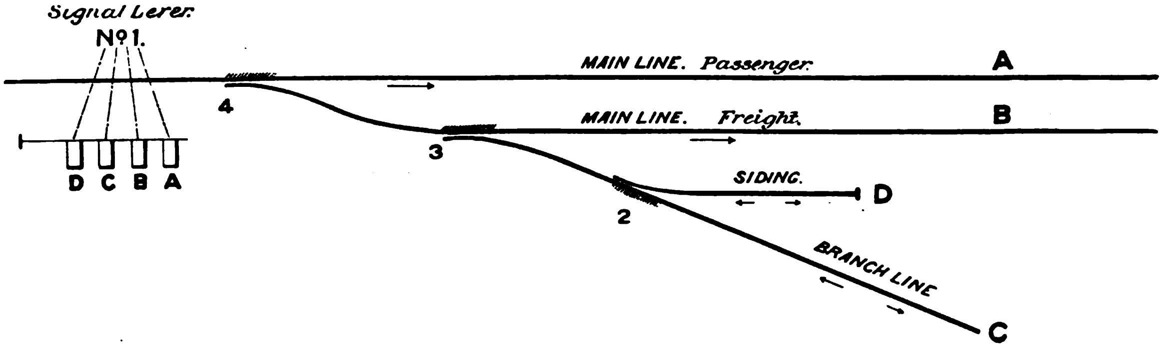
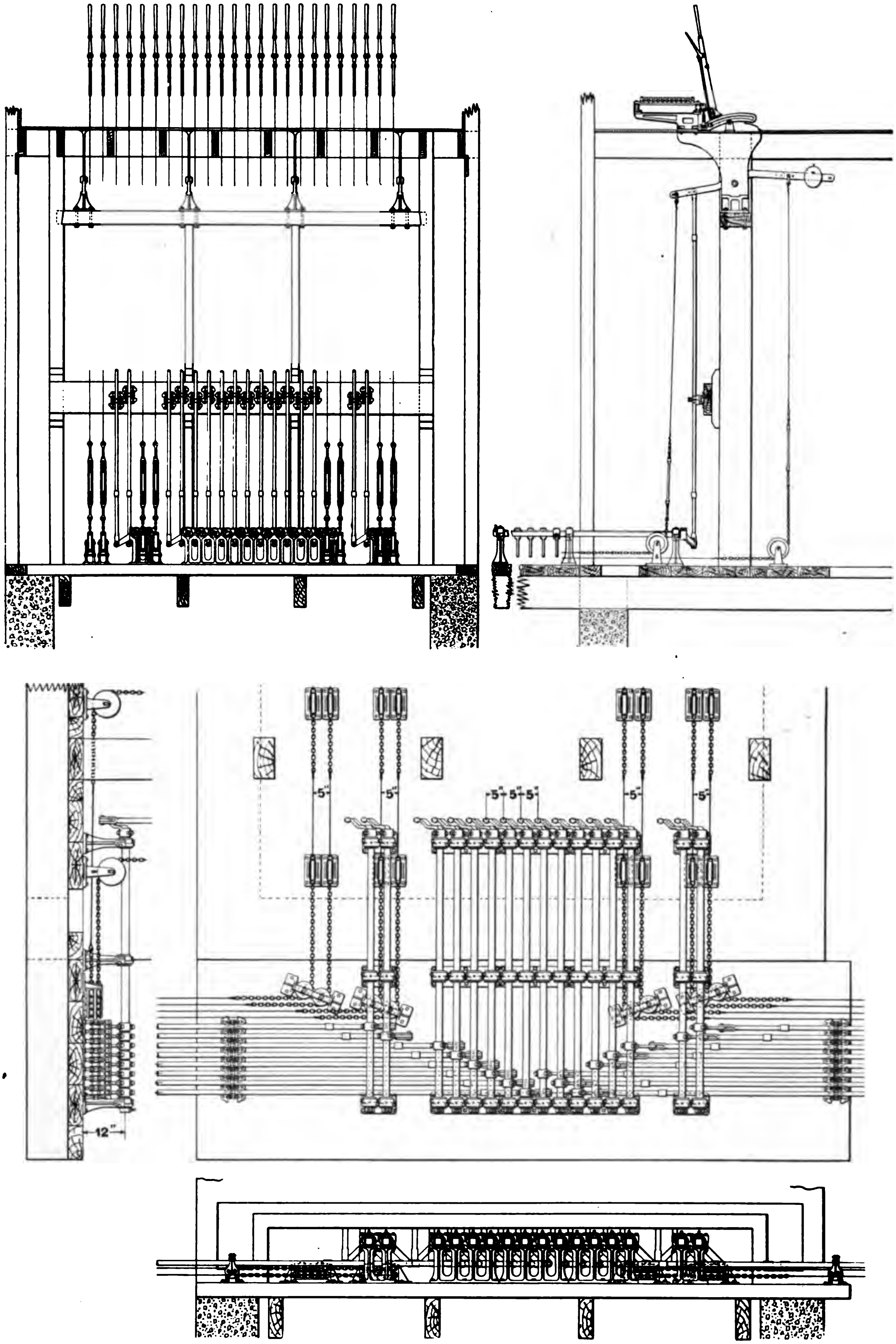
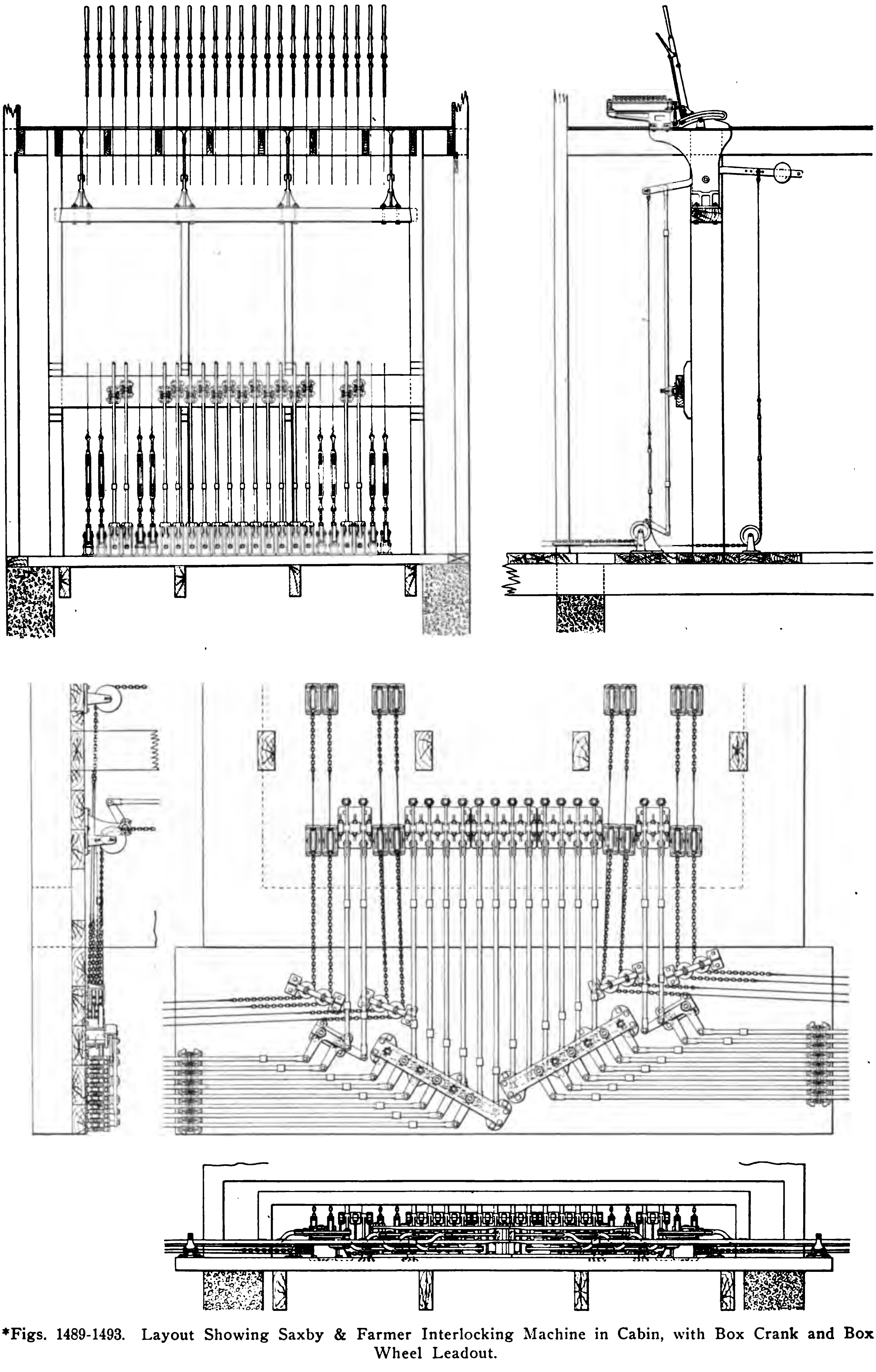


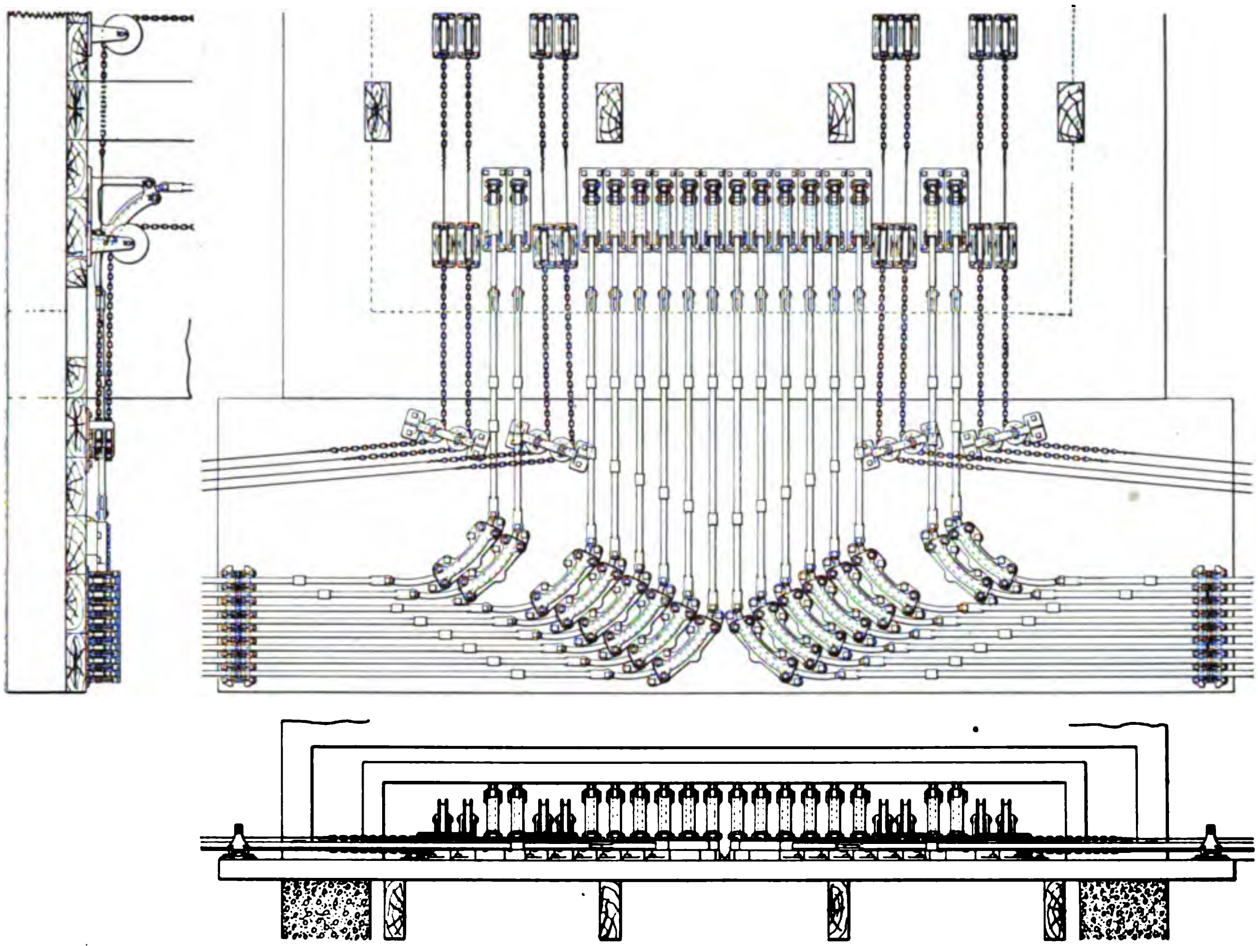
Fig. 1483. Track Diagram Showing Application of Selector Illustrated in Fig. 1482.



*Figs. 1484-1488. Layout Showing Saxby & Farmer Interlocking Machine in Cabin, with Rocker Shaft and Box Wheel Leadout.



*Figs. 1489-1493. Layout Showing Saxby & Farmer Interlocking Machine in Cabin, with Box Crank and Box Wheel Leadout.



*Figs. 1494-1496. Layout Showing Deflecting Bar Leadout.

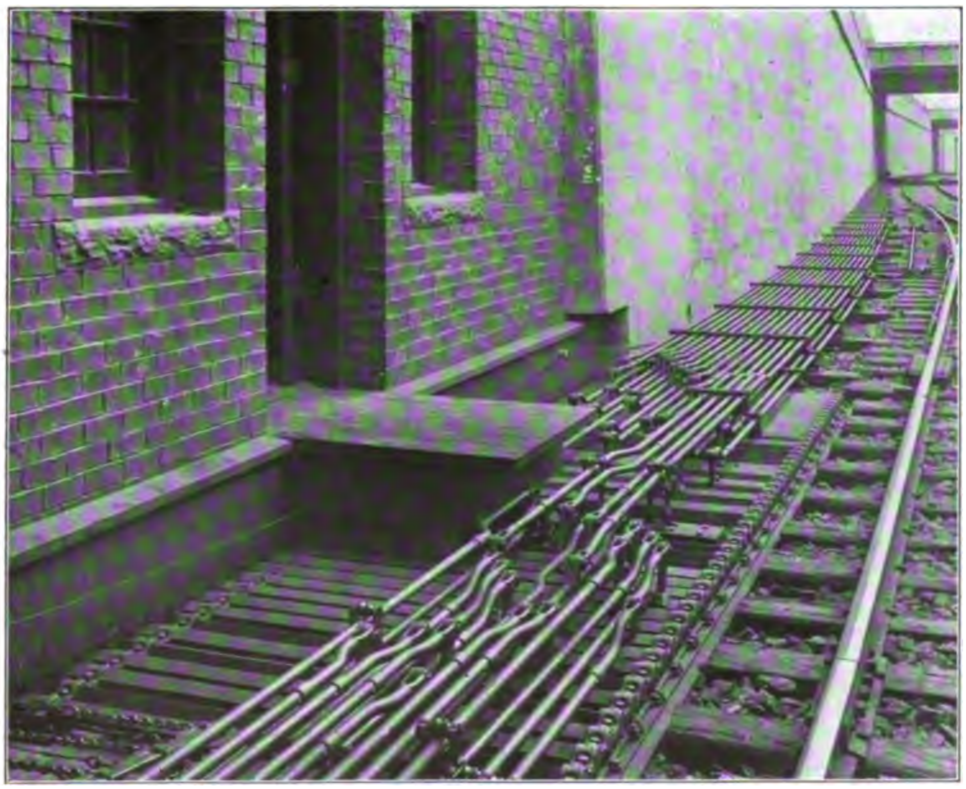
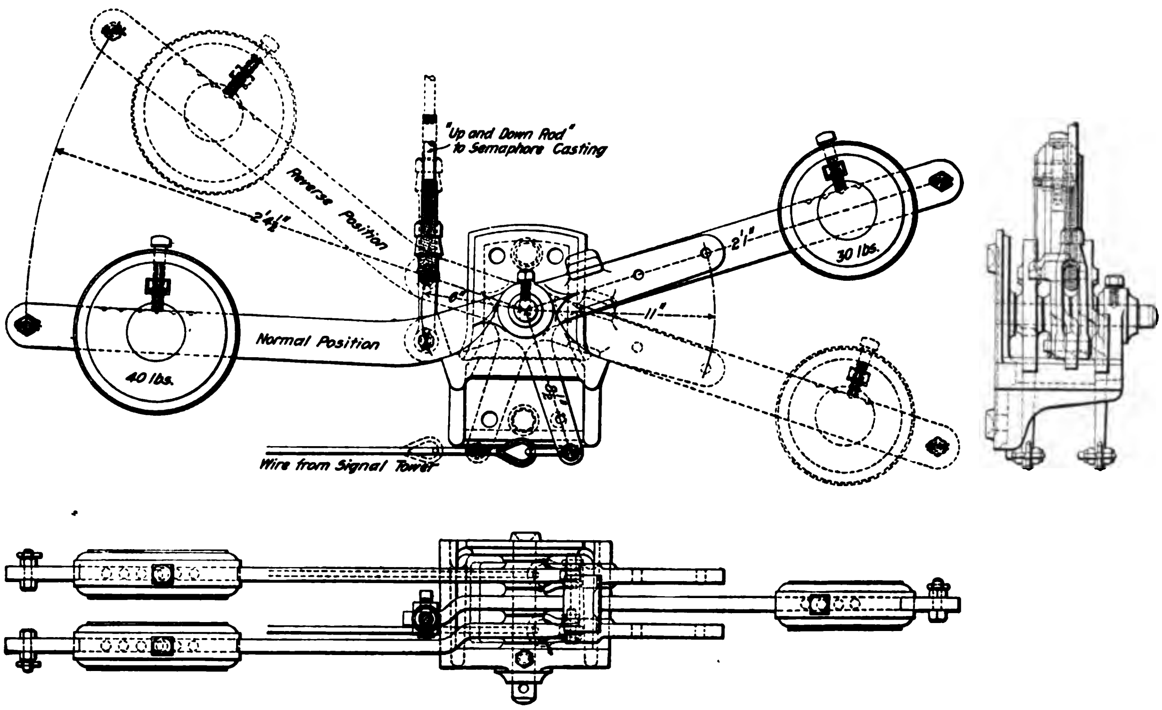
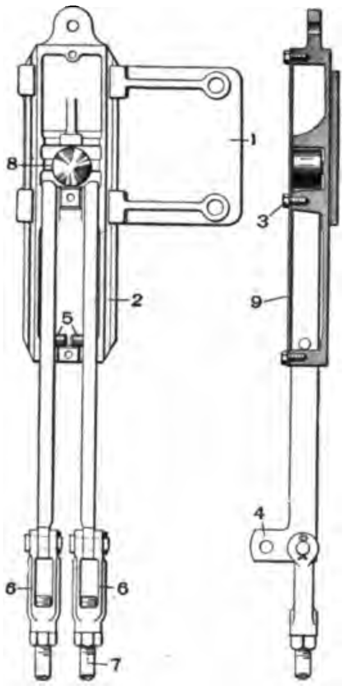


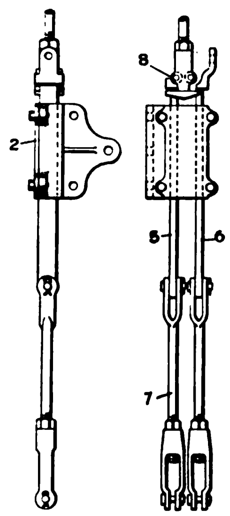
Fig. 1497. Inverted Rocker Shaft Leadout and Double-Deck Pipe Line. Delaware, Lackawanna & Western.



Figs. 1498-1500. Single Wire Mechanical Slot. Great Western of England.



*Figs. 1501-1502. Mechanical Slot.



*Figs. 1503-1504. Mechanical Slot, Johnson Type.

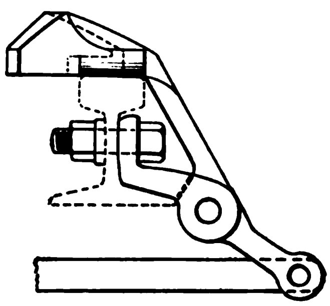


Fig. 1505. Lifting Derail. Railroad Supply Company.

Names of Parts, Mechanical Slot; Figs. 1501-1502.

1 *Slot Guide*	4 *Right Hand Vertical Slide*	7 *Connecting Rod*
2 *Slide*	5 *Rivet Stop*	8 *Roller*
3 *Tap Bolt*	6 *Screw Jaw*	9 *Cover*

Names of Parts, Johnson Type Mechanical Slot; Figs. 1503-1504.

2 *Slot Case and Cover*	6 *Right Hand Vertical Slide*	8 *Roller*
5 *Left Hand Vertical Slide*	7 *Coupling Rod*	

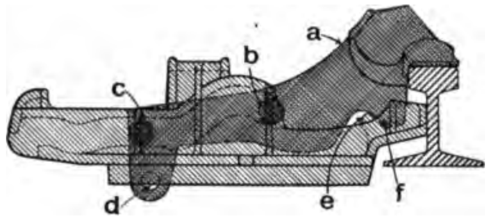


Fig. 1506. Derail Open.

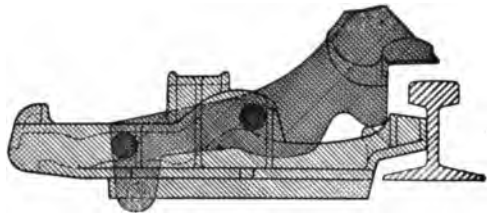


Fig. 1507. Derail Lifting.

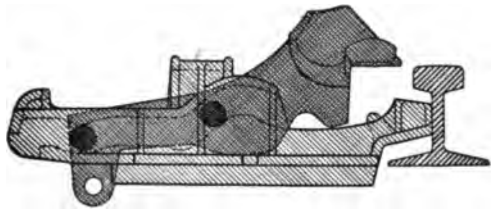


Fig. 1508. Derail Dropping.

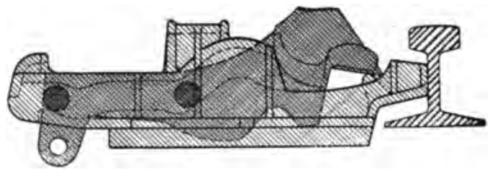


Fig. 1509. Derail Closed.

Figs. 1506-1509. Hayes Derail, Successive Positions.

Fig. 1510. Hayes Derail Open.

Fig. 1511. Hayes Derail, with Extra Connection for Bolt Lock.

Fig. 1512. Hayes Derail, Pivoted Type, Open.

Fig. 1513. Hayes Derail, Pivoted Type, Closed.

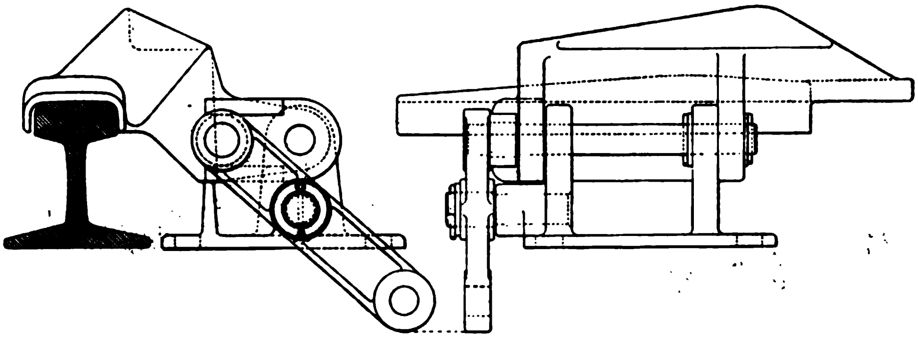
Fig. 1514. Hayes Lifting Derail, Operated by Hand Throw Switch Stand.

four-hook tower selector and a track diagram showing its application. The signals are wire connected. The pull wires are attached to hooks in the selector, all of which, except that to arm A, are normally disengaged from the dog at the end of the rod operated by lever No. 1. When switch 4 is reversed A is disengaged and B is engaged by the action of the cam on the shaft actuated by lever 4. When 3 and 4 are both reversed B is disengaged and C engaged. Reversal of 2, 3 and 4 disengages C and engages D. A similar arrangement can be used with pipe connected signals.

LEADOUTS.

The leadout or arrangement of apparatus by which the operating connections are carried from the machine out of the tower consists of a foundation or platform forming an extension of the tower floor and the leadout devices which are mounted thereon. These may consist of rocker shafts, Figs. 1484-1488, box cranks, Figs. 1489-1493, deflecting bars, Figs. 1494-1496, on any combination of the three. The rockers may be inverted where clearances demand (Fig. 1497). Rocker shafts are made of hexagonal or square

Fig. 1515. Hayes Derail Operated by Electric Switch Movement. Baltimore & Ohio.

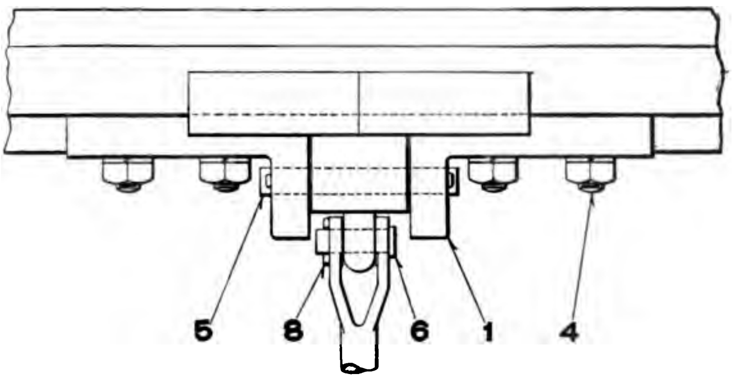


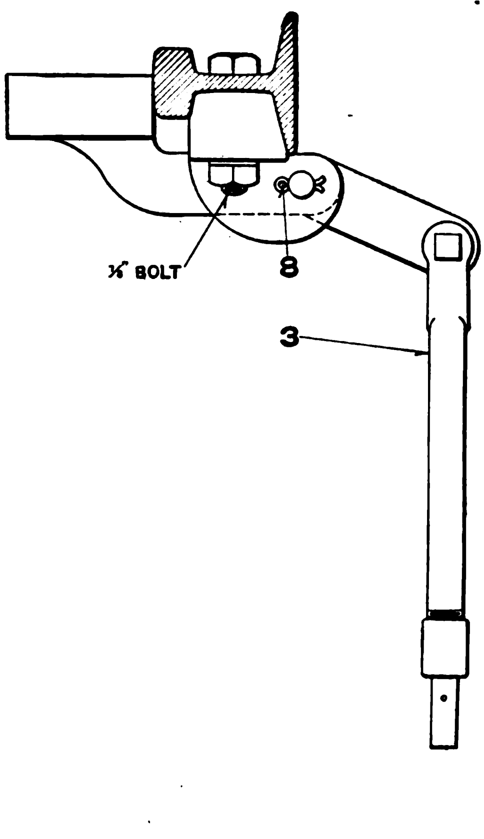
Figs. 1516-1517. Anderson-Bevan Derail. General Railway Signal Company.

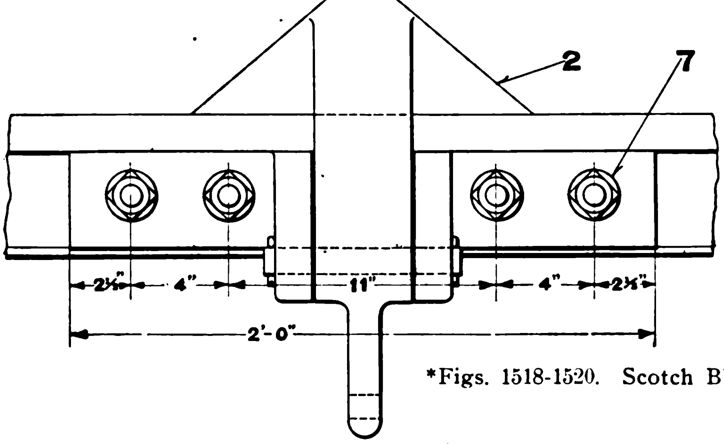
Names of Parts; Scotch Block; Figs. 1518-1520.

1 *Bearing*
2 *Wedge Block*
3 *Tang End Jaw*
4 ⅞" x 5" *Bolt*
5 1" x 8" *Bearing Shaft*
6 *Pin*
7 *Washer*
8 *Cotter*

Numbers Refer to List of Names Above.



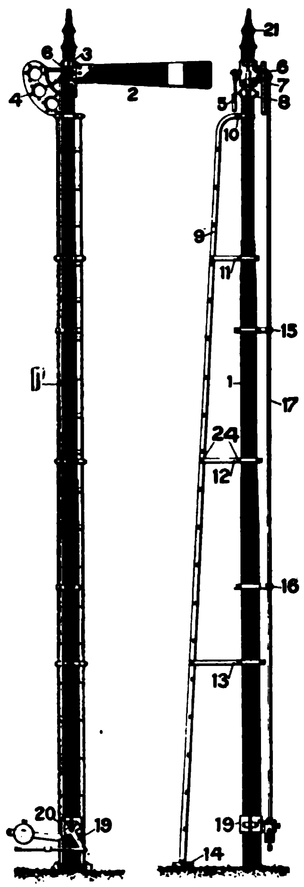




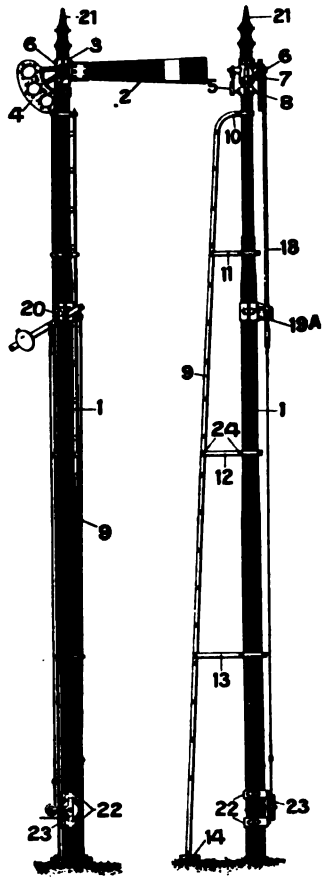
*Figs. 1518-1520. Scotch Block.

steel bars mounted in bearings Figs. 1408-1416. They carry arms to which the vertical rods and pipe lines are attached. A box crank is a frame in which a number of cranks are mounted (Figs. 1442-1450). A box crank leadout requires more space than a rocker shaft leadout, but is more accessible. Where box cranks are used the vertical rods must be attached to vertical cranks (Figs. 1017-1022). Separate pin leadout cranks (Figs. 1444-1448) are sometimes used. Deflector bar leadouts are seldom used. They take up

Numbers Refer to List of Names of Parts on Page Opposite Figs. 1529-1532.

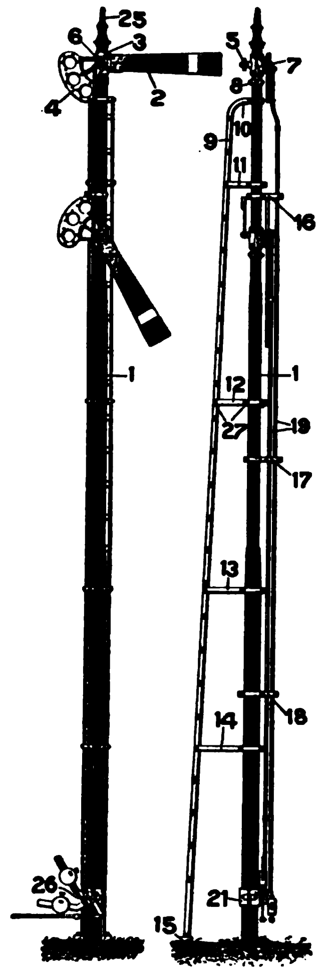


Figs. 1521-1522. Pipe Connected.

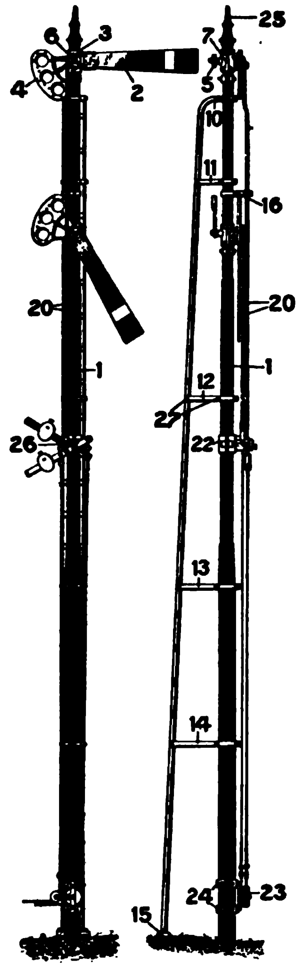


Figs 1523-1524. Wire Connected.

One Arm.



Figs. 1525-1526. Pipe Connected.



Figs. 1527-1528. Wire Connected.

Two Arm.

*Figs. 1521-1528. Iron Pipe Post Mechanical Interlocking Signals.

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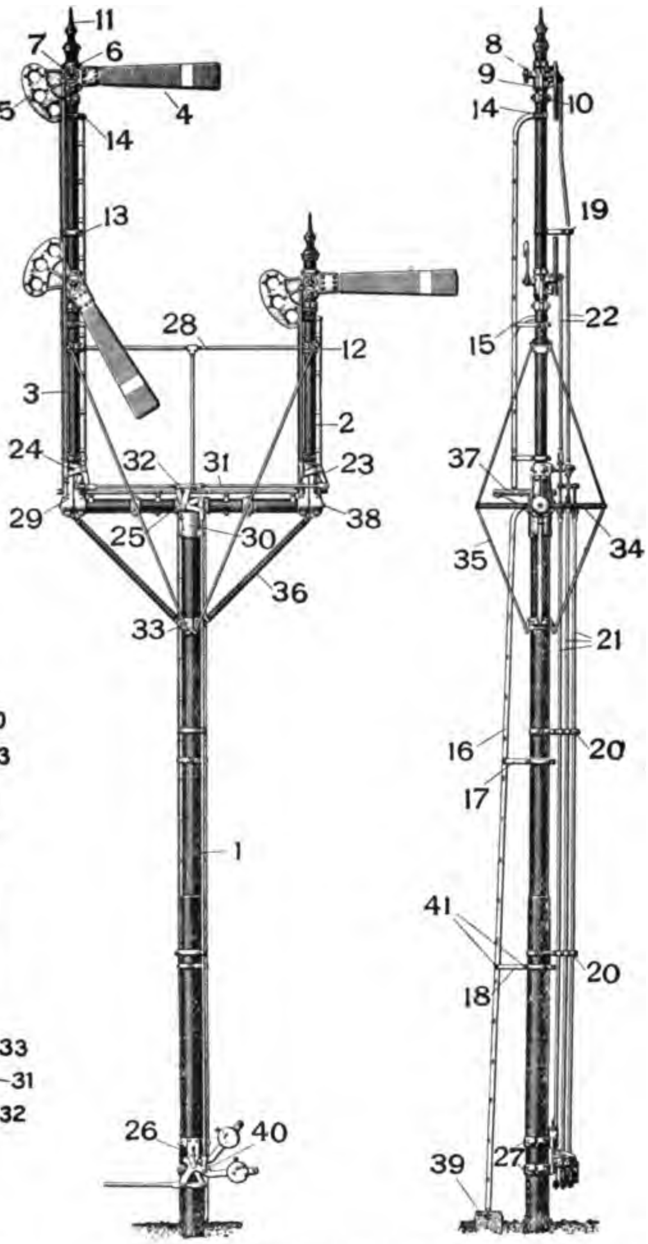
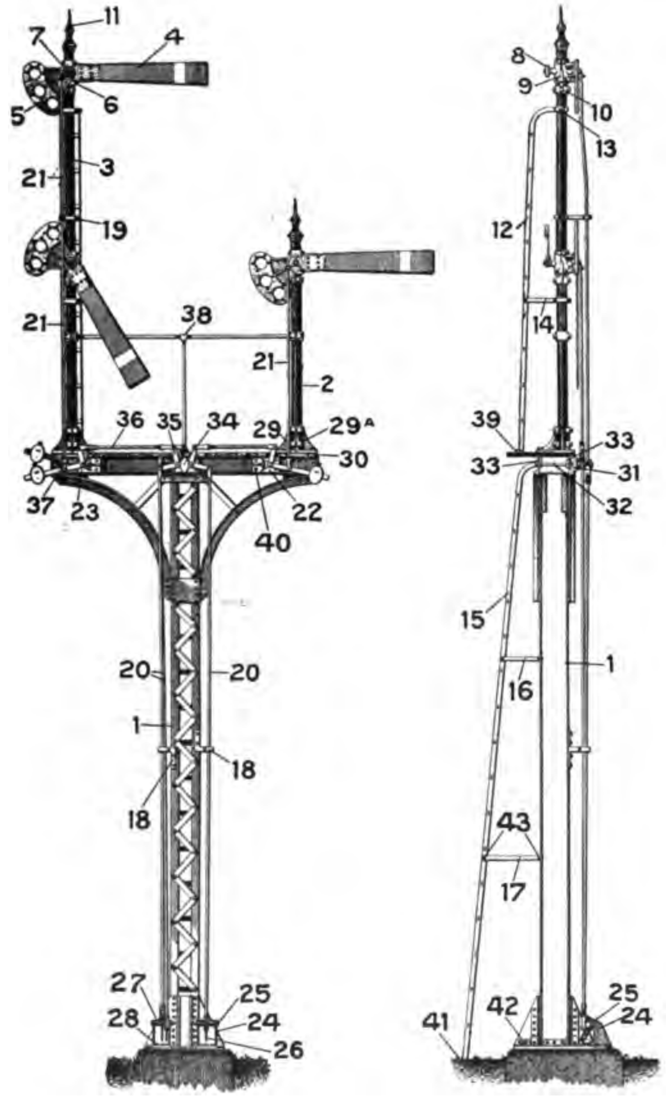


*Figs. 1531-1532. Three-Arm Iron Pipe Post Mechanical Interlocking Bracket Signal.



*Figs. 1529-1530. Three-Arm Lattice Post Mechanical Interlocking Bracket Signal.

less room than any other style of leadout appliance but are somewhat liable to develop lost motion.

OIL PIPES

Where it is necessary to run pipe lines under ground, as through a street, it is customary to enclose the 1 in. pipe in 2 in. or 2½ in. galvanized pipe filled with oil. Stuffing boxes and plungers are provided at the ends to prevent the oil from escaping, and cranks are mounted in oil boxes. The weight of the earth on the large pipe is usually sufficient to hold it in line, no foundations being necessary (Figs. 1433-1441). When it is desired to run wires under ground galvanized pipe is used and stuffing boxes (Figs. 1273-1274) are provided.

Names of Parts, One Arm Iron Pipe Post Mechanical Interlocking Signal; Figs. 1521-1524.

1 *Iron Pipe Post*
2 *Blade*
3 *Semaphore Bearing*
4 *Spectacle*
5 *Back Spectacle*
6 *Semaphore Shaft*
7 *Lamp Bracket*
8 *Lamp Bracket Clamp*
9 *Ladder*
10 *Ladder Clamp*
11 *Ladder Stay*
12 *Ladder Stay*
13 *Ladder Stay*
14 *Ladder Foundation*
15 *Pipe Guide*
16 *Pipe Guide*
17 *Up and Down Rod*
18 *Up and Down Rod*
19 *Balance Lever Stand with Clamp for Pipe Connected Signal*
19A *Balance Lever Stand with Clamp for Wire Connected Signal*
20 *Screw Jaw*
21 *Pinnacle*
22 *Signal Wheel Clamp*
23 *Signal Wheel*
24 *Ladder Stay Bolt*

Names of Parts, Two Arm Iron Pipe Post Mechanical Interlocking Signal; Figs. 1525-1528.

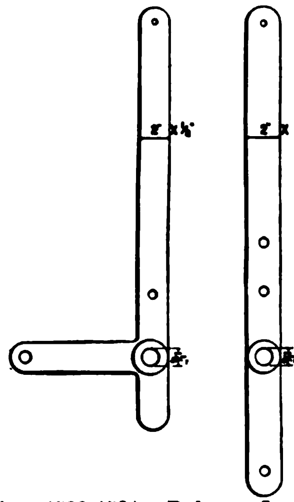
1 *Iron Pipe Post*
2 *Blade*
3 *Semaphore Bearing*
4 *Spectacle*
5 *Back Spectacle*
6 *Semaphore Shaft*
7 *Lamp Bracket*
8 *Lamp Bracket Clamp*
9 *Ladder*
10 *Ladder Clamp*
11 *Ladder Stay*
12 *Ladder Stay*
13 *Ladder Stay*
14 *Ladder Stay*
15 *Ladder Foundation*
16 *One Way Pipe Guide*
17 *Two Way Pipe Guide*
18 *Two Way Pipe Guide*
19 *Up and Down Rods for Pipe Connected Signal*
20 *Up and Down Rods for Wire Connected Signal*
21 *Two Way Balance Lever Stand with Clamp for Wire Connected Signal*
22 *Two Way Balance Lever Stand with Clamp for Wire Connected Signal*
23 *Two Way Signal Wheel*
24 *Signal Wheel Clamp*
25 *Pinnacle*
26 *Screw Jaw*
27 *Ladder Stay Bolt*

Names of Parts, Three Arm Iron Pipe Post Mechanical Interlocking Bracket Signal; Figs. 1531-1532.

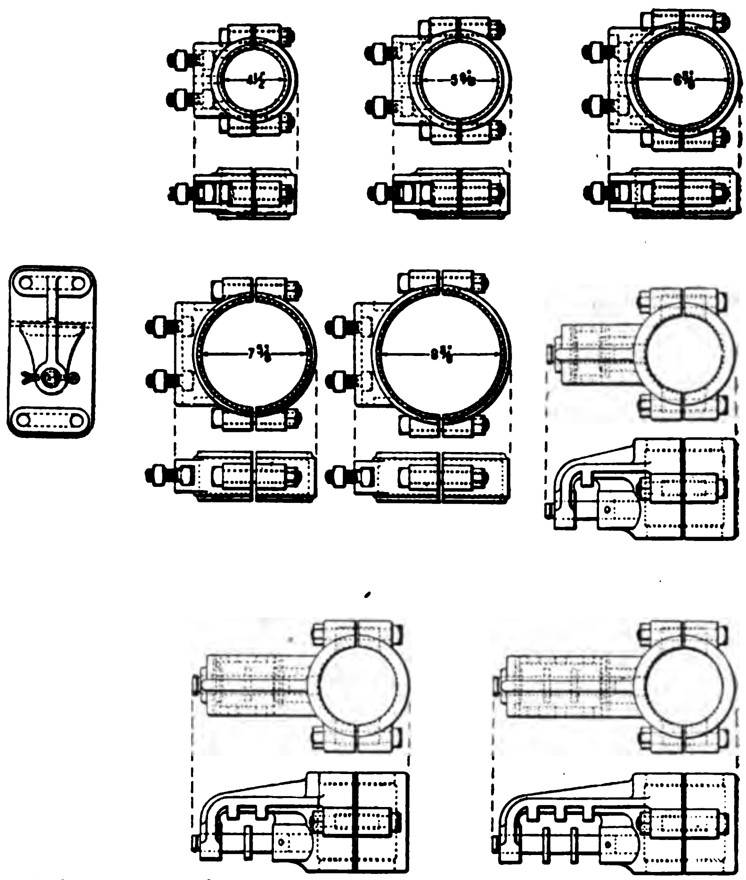
1 *Main Iron Pipe Post*
2 *Iron Pipe Doll Post for One Arm*
3 *Iron Pipe Doll Post for Two Arms*
4 *Blade*
5 *Spectacle*
6 *Semaphore Bearing*
7 *Semaphore Shaft*
8 *Back Spectacle*
9 *Lamp Bracket*
10 *Lamp Bracket Clamp*
11 *Pinnacle*
12 *Short Doll Ladder*
13 *Long Doll Ladder*
14 *Doll Ladder Clamp*
15 *Doll Ladder Stay*
16 *Main Ladder*
17 *Main Ladder Stay*
18 *Main Ladder Stay*
19 *One Way Pipe Guide*
20 *Three Way Pipe Guide*
21 *Main Up and Down Rods*
22 *Doll Up and Down Rods*
23 *One Way Doll Crank Stand with Clamp*
24 *Two Way Doll Crank Stand with Clamp*
25 *Three Way Crank Stand with Clamp*
26 *Three Way Balance Lever Stand*
27 *Balance Lever Stand Clamp*
28 *Hand Rail*
29 *Doll Sockets*
30 *Cross Tree Clamp*
31 *Connecting Rod*
32 *Crank*
33 *Guy Rod and Pipe Knee Clamp*
34 *Guy Rod Strut*
35 *Guy Rod*
36 *Pipe Knee*
37 *Platform*
38 *Cross Tree End Cover*
39 *Ladder Foundation*
40 *Screw Jaw*
41 *Ladder Staybolt*

Names of Parts, Three Arm Lattice Post Mechanical Interlocking Bracket Signal; Figs. 1529-1530.

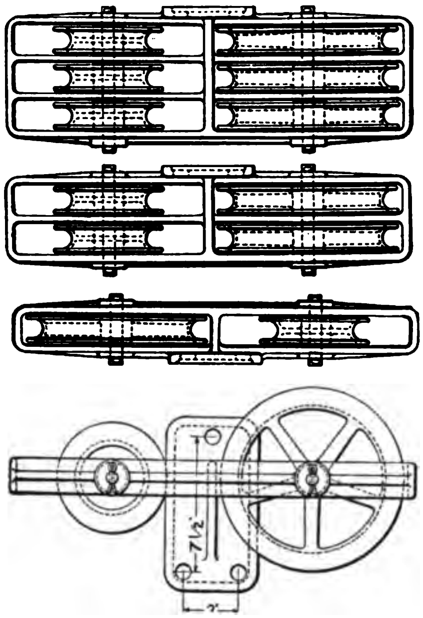
1 *Lattice Post*
2 *Iron Pipe Doll Post for One Arm*
3 *Iron Pipe Doll Post for Two Arms*
4 *Blade*
5 *Spectacle*
6 *Semaphore Bearing*
7 *Semaphore Shaft*
8 *Back Spectacle*
9 *Lamp Bracket*
10 *Lamp Bracket Clamp*
11 *Pinnacle*
12 *Doll Ladder*
13 *Doll Ladder Clamp*
14 *Doll Ladder Stay*
15 *Main Ladder*
16 *Main Ladder Stay*
17 *Main Ladder Stay*
18 *Pipe Guide*
19 *Pipe Guide*
20 *Main Up and Down Rod*
21 *Doll Up and Down Rod*
22 *One Way Balance Lever Stand*
23 *Two Way Balance Lever Stand*
24 *One Way Vertical Crank*
25 *Crank Stand Pin*
26 *Crank*
27 *Washer*
28 *Anchor Bolt*
29 *Right Hand Base Clamp for Doll Post*
29A *Left Hand Base Clamp for Doll Post*
30 *Right Hand Filler Channel Iron for* **29**
31 *Cast Iron Filler Block for* **22, 23** *or* **34**
32 *Tie Bolt*
33 *Eye Bolt*
34 *Special Three Way Crank Stand*
35 *Crank*
36 *Connecting Rod*
37 *Screw Jaw*
38 *Hand Rail*
39 *Platform*
40 *Bolt*
41 *Ladder Foundation*
42 *Anchor Bolt*
43 *Ladder Stay Bolt*



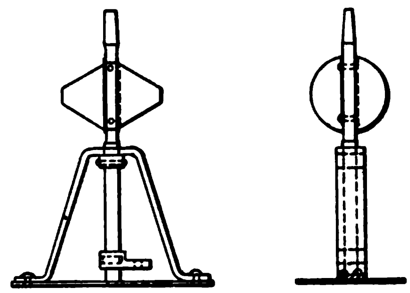
*Figs. 1533-1534. Balance Levers.



*Figs. 1539-1547. Clamps and Clamp Crank Stands for Iron Pipe Posts.



*Figs. 1535-1538. Types of Signal Wheels.



Figs. 1550-1551. Target and Stand, Sometimes Used in Place of Pot Signals. New York Central & Hudson River.

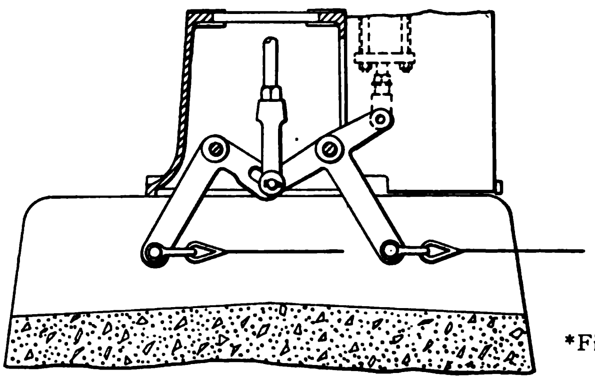


Fig. 1548. Electro-Pneumatic High Signal, Fitted to be Operated by Wire. Pennsylvania Railroad.

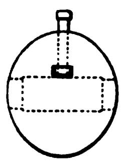


*Fig. 1549. Counterweight.

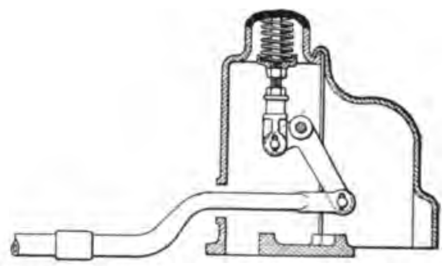


Fig. 1552. Electro-Pneumatic Dwarf Signal, Fitted for Pipe Operation. Pennsylvania Railroad.

NOTE.—Figs. 1548 and 1552-1553 show how electro-pneumatic signals with mechanism removed may be operated as mechanical signals, thus making one form of apparatus serve for two kinds of interlocking.

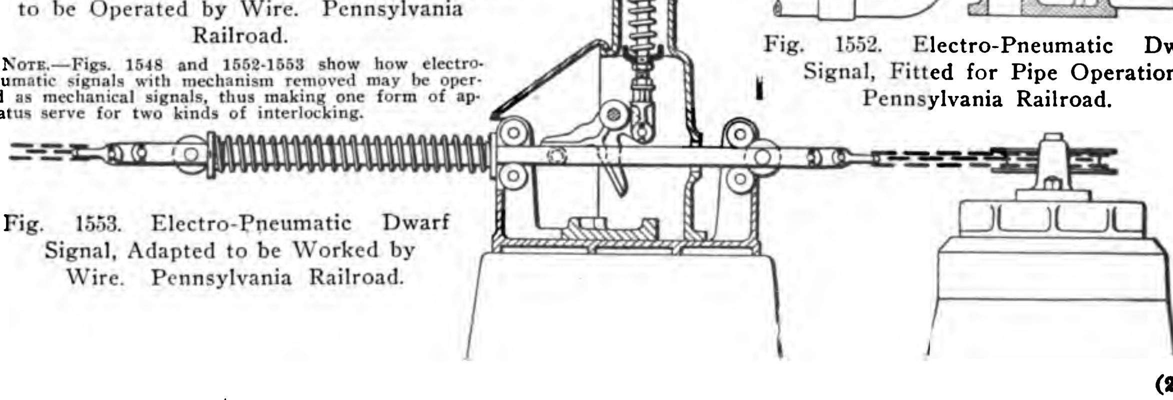
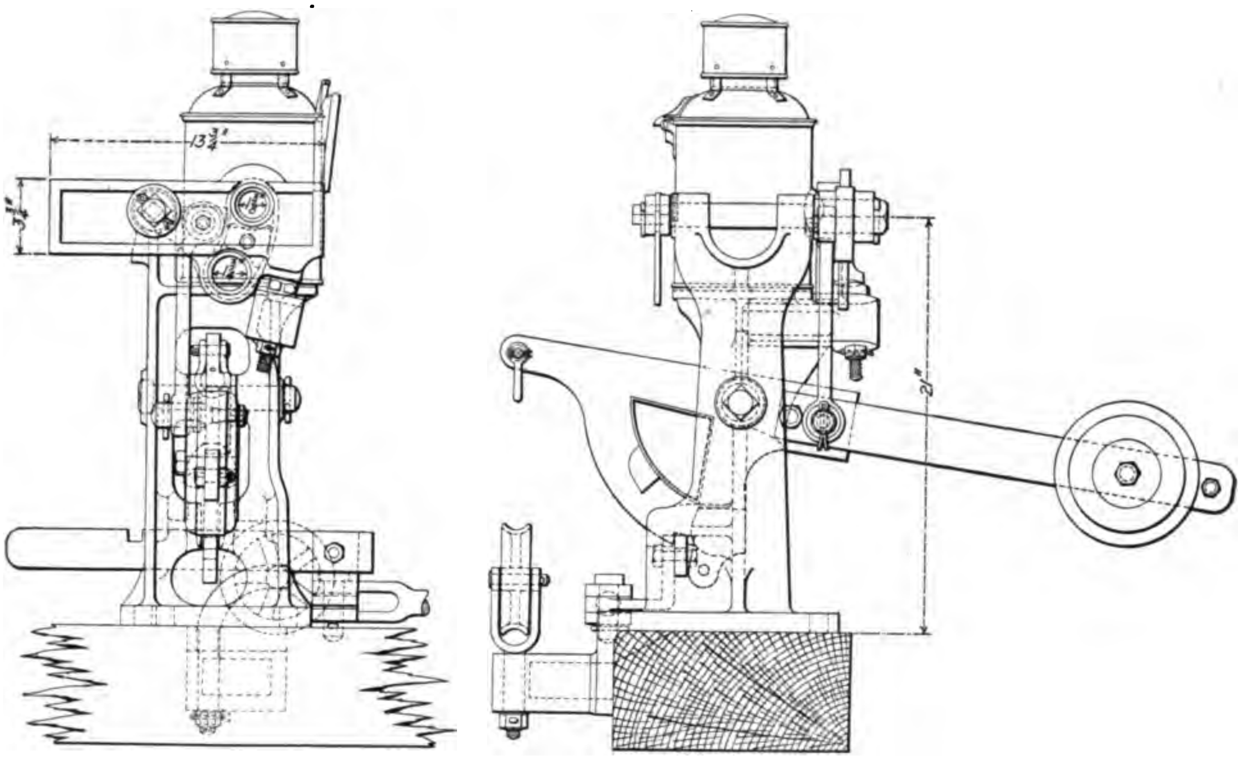


Fig. 1553. Electro-Pneumatic Dwarf Signal, Adapted to be Worked by Wire. Pennsylvania Railroad.



Figs. 1554-1555. Single Wire Dwarf Signal and Point Detector Combined. Great Western of England.

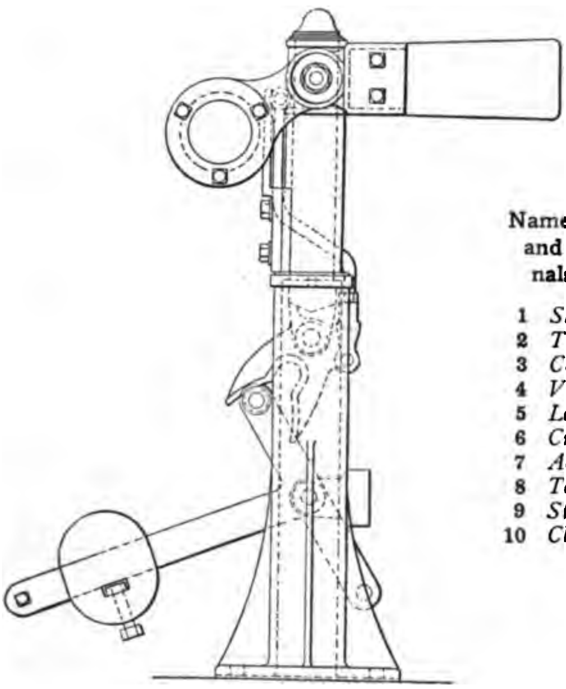
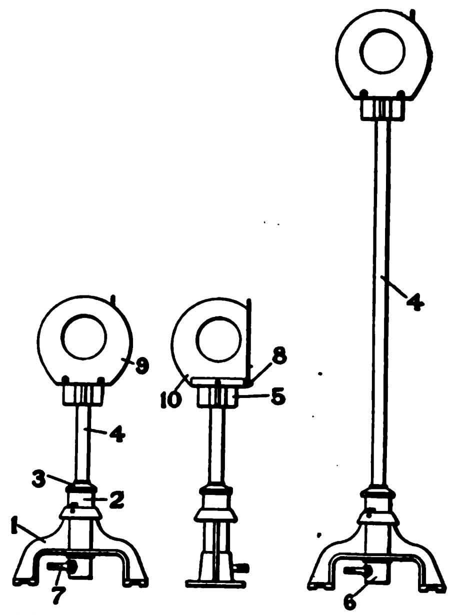


*Fig. 1556. Compensating Dwarf Signal.

Names of Parts, High and Low Pot-Signals; Figs. 1557-1559.

1 *Stand*
2 *Top Bearing Bushing*
3 *Collar*
4 *Vertical Shaft*
5 *Lamp Base*
6 *Crank Bushing*
7 *Adjustable Eye Bolt*
8 *Tap Bolt*
9 *Stop Target*
10 *Clear Target*



*Figs. 1557-1559. Types of Pot Signals.

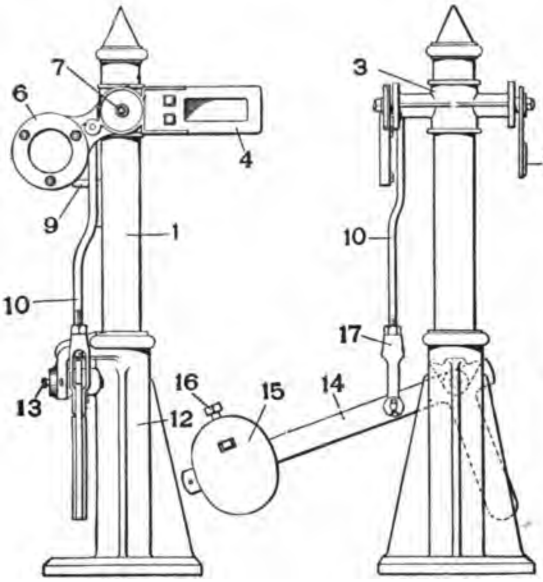
MECHANICAL SLOTS.

Where it is desired to control one signal from two interlocking machines mechanically, a slot such as is shown in Figs. 1501-1502, may be used. This consists of a slide 2 moving in guides on casting 1, the latter being fastened to the signal post. Two vertical rods, one operated from each interlocking machine, move in 2. The connection to the semaphore casting is attached to the top of 2. The vertical rods strike against roller 8 when raised. If only one rod is raised the roller will move to one side out of its path; but if both are raised together, or one is raised while the other is already up, the roller will strike against the lug above it and the whole slide 2 will move upward and clear the signal. Stops 5 engage the bottom of slide 2 and assure its return to normal position when either rod is lowered. Lug 4 is used when the slot is applied to a double arm home and distant signal, when the home is controlled from one point and the distant from another. The home signal is actuated by a rod attached to 4 and the distant signal by a rod attached to the top of 2. Thus the distant arm cannot be cleared while the home arm is in the stop position. Another style of mechanical slot is shown in Figs. 1503-1504. The case 1 is fastened to the signal pole. Rods 5 and 6 move through the case which acts as a guide. The signal up and down rod is attached to the swing jaw which is equipped with two rollers 8 and a triangular lug. Dogs at top of rods 5 and 6 strike against the rollers when raised. Raising of one rod only, pushes 8 over to the other side and does not affect the signal. Raising of both rods together or separately raises the up and down rod and clears the signal. Dogs on the ends of rods 5 and 6 engage with the triangular lug to insure that the signal will be restored to the stop position when either rod is lowered. The upper end of rod 6 is equipped with a lug to which the home signal is attached when home and distant are on same pole, as explained in connection with Figs. 1501-1502.

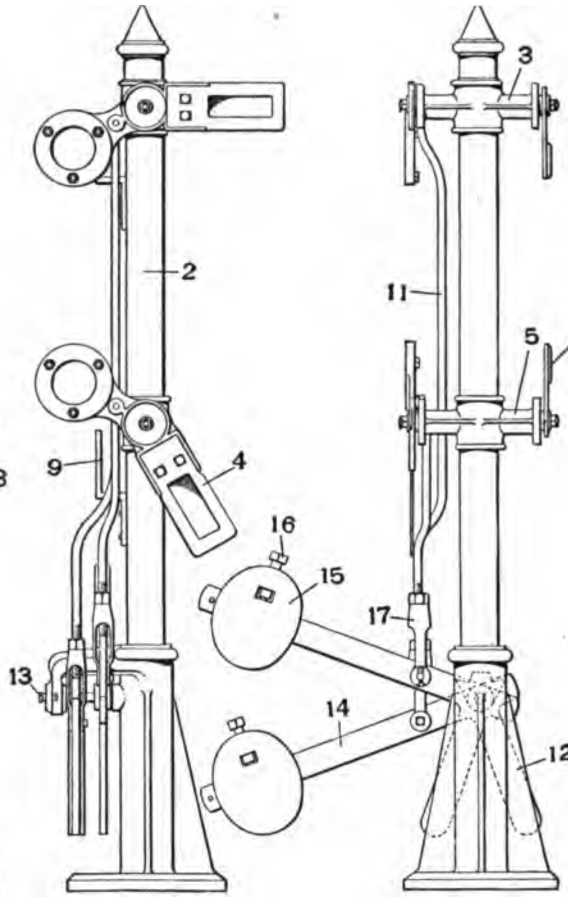
Figs. 1479-1481 show how a three-position signal may be operated by two levers and one pipe line. A floating lever is introduced between the two machine tail levers, and to this the pipe line is attached. The illustration shows the position of the apparatus corresponding to each position of the signal.

Names of Parts, Dwarf Signals; Figs. 1560-1563.

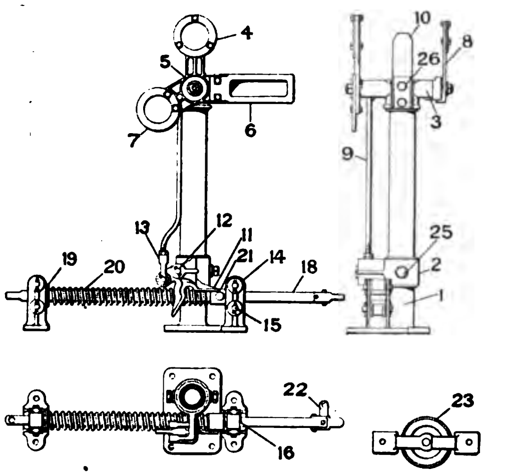
1	*Iron Pipe Post*	10	*Up and Down Rod*
2	*Iron Pipe Post*	11	*Up and Down Rod*
3	*Semaphore Bearing*	12	*Base*
4	*Blade*	13	*Pin*
5	*Semaphore Bearing*	14	*Balance Lever*
6	*Spectacle*	15	*Counterweight*
7	*Semaphore Shaft*	16	*Counterweight Bolt*
8	*Back Spectacle*	17	*Screw Jaw*
9	*Lamp Bracket*		



*Figs. 1560-1561. One-Arm Dwarf Signal.



*Figs. 1562-1563. Two-Arm Dwarf Signal.



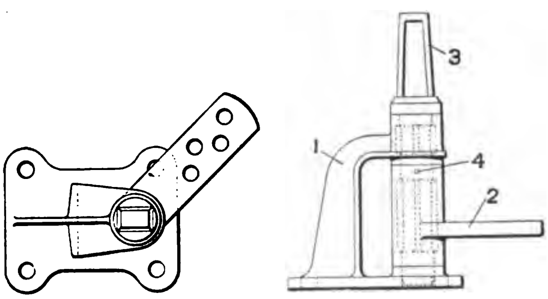
*Figs. 1564-1567. One-Arm Dwarf Signal, with Spring Restoring Attachment.

Names of Parts, One-Arm Dwarf Signals with Spring Attachment; Figs. 1564-1567.

1	*Post and Base*	13	*Screw Jaw*
2	*Crank Bearing*	14	*Guide Stand*
3	*Semaphore Bearing*	15	*Pin and Cotter*
4	*Spectacle*	16	*Roller*
5	*Semaphore Shaft*	18	*Operating Shaft*
6	*Blade*	19	*Spring Plate*
7	*Disc*	20	*Spring*
8	*Back Spectacle*	21	*Trunnion Block*
9	*Up and Down Rod*	22	*Double Lug*
10	*Lamp Bracket*	23	*6-in. Wheel and Stand*
11	*Escapement Crank*	25	*Tap Bolt*
12	*Center Pin*	26	*Tap Bolt*

Names of Parts, Switch Light Stand; Figs. 1568-1569.

1	*Stand*	3	*Lamp Spindle*
2	*Crank Arm*	4	*Dowel Pin*



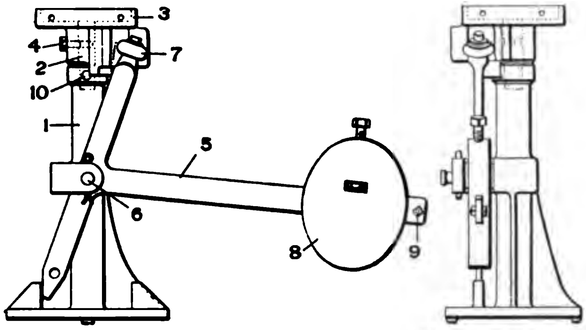
*Figs. 1568-1569. Switch Light Stand.

DERAILS.

When it is desired to be sure that a train will not run past a stop signal (as in the case of grade crossings, drawbridges, etc.), it is customary to provide means of derailing the train if it should do so, by using some form of derailing switch. This often consists of one-half of an ordinary split point switch; that is, the half that is closed for main track movements, the other side of the track being a continuous rail. There are other ways of accomplishing the same result.

The Hayes derail (Figs. 1506-1511) consists of two parts, the derail block and the guide box. Both parts are malleable castings. Figs. 1506-1509 show successive positions of the block while being closed. The block shown in heavy shading carries four guide pins, *b-c*, Fig. 1506, two on each side. These slide in cam slots in the guide box. The lug *f*, rests against seat *e* when the derail is open (Fig. 1506). This seat takes the thrust at right angles to the rail. The block cannot leave the rail without rising above the seat, therefore a wheel passing over the block only serves to hold it more firmly in place. Thrust parallel to the rail is taken by the guide box. There are 2 lugs *d* with holes for attaching to operating and locking devices. Fig. 1510 is a view of the derail just described in place. Fig. 1511 is a slightly heavier design. It has an eye bolt between the two lugs (shown at *d*, Fig. 1506), to which a bolt lock or switch box may be attached independent of the lock rod. Figs. 1512-1513 show a different model designed to be operated by hand only. It cannot be attached to an operating rod. The two castings are riveted together, the derail block moving on a pivot.

The Anderson-Bevan derail (Figs. 1516-1517) made by the General Railway Signal Company, consists of a derailing block mounted



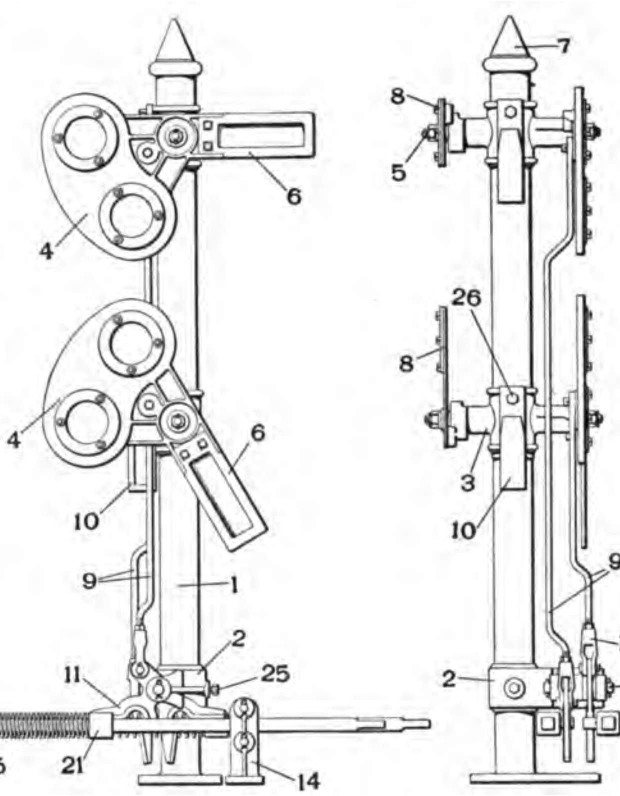
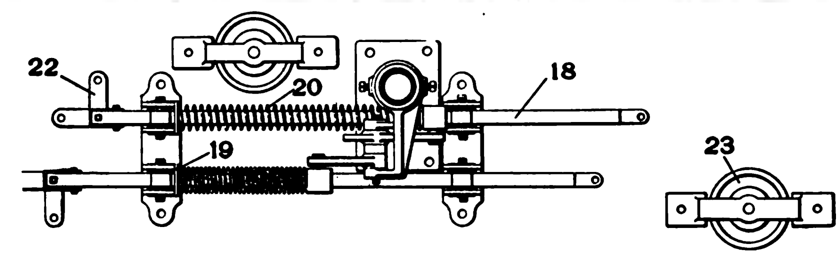
Figs. 1570-1571. Compensating Pot Signal; Johnson Type.

Names of Parts, Compensating Pot Signal, Johnson Type; Figs. 1570-1571.

1 *Stand*	6 *Pin*
2 *Stud*	7 *Roller*
3 *Lamp Base*	8 *Counterweight*
4 *Set Screw*	9 *Stop Bolt*
5 *Balance Lever*	10 *Dowel Pin*

Names of Parts, Two-Arm Dwarf Signal with Restoring Springs; Figs. 1572-1575.

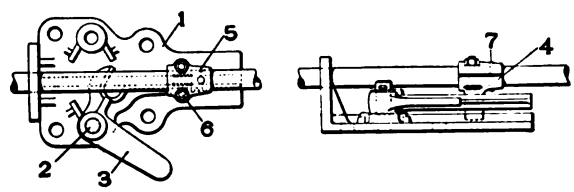
1 *Combination Base and Pole*
2 *Two Way Crank Stand*
3 *Lower Semaphore Bearing*
4 *Spectacle*
5 *Semaphore Shaft*
6 *Blade*
7 *Pinnacle*
8 *Back Spectacle*
9 *Up and Down Rod*
10 *Lamp Bracket*
11 *Escapement Crank*
12 *Screw Jaw*
13 *Pin*
14 *Two Way Guide Stand*
15 *Pin with Cotters*
18 *Operating Shaft with Eye*
19 *Spring Plate*
20 *Spring*
21 *Trunnion Block*
22 *Double Lug*
23 *6-in. Chain Wheel and Stand*
25 *Tap Bolt*
26 *Tap Bolt*

*Figs. 1572-1575. Two-Arm Dwarf Signal, with Restoring Springs.

Names of Parts, Special Dwarf Signal Movement; Figs. 1576-1577.

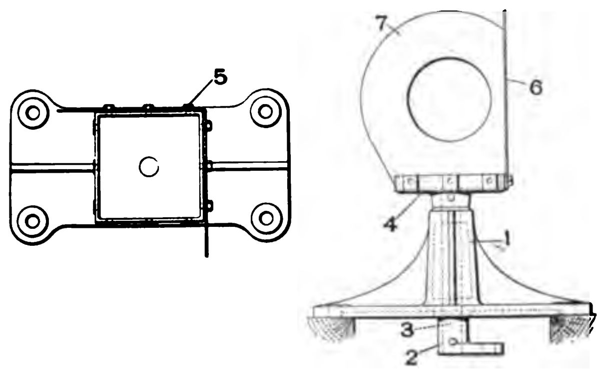
1 *Stand*
2 *Stud with Cotter*
3 *Escapement Crank*
4 *Trunnion*
5 *Trunnion Cap*
6 *Bolt*
7 *Rivet*



Figs. 1576-1577. Special Dwarf Signal Movement.

Names of Parts of Low Pot Signal; Figs. 1578-1579.

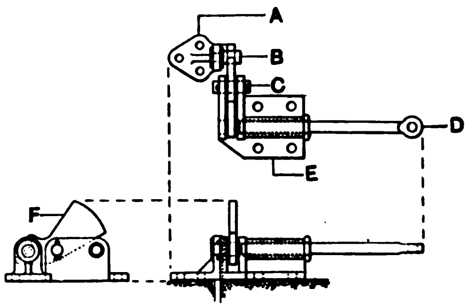
1 *Stand*
2 *Crank*
3 *Crank Shaft*
4 *Lamp Base*
5 *Tap Bolt*
6 *Stop Target*
7 *Clear Target*



*Figs. 1578-1579. Low Pot Signal.

in a stand designed to be fastened to a tie. The block is carried on an arm pivoted in the stand so that it can swing on and off of the rail. The block has a channel in the bottom which rests over the rail head and takes the lateral thrust. Connection is made to the operating apparatus through a centrally pivoted lever whose upper end carries a lug acting in a cam slot on the side of the block. This also takes care of any overstroke in the connections.

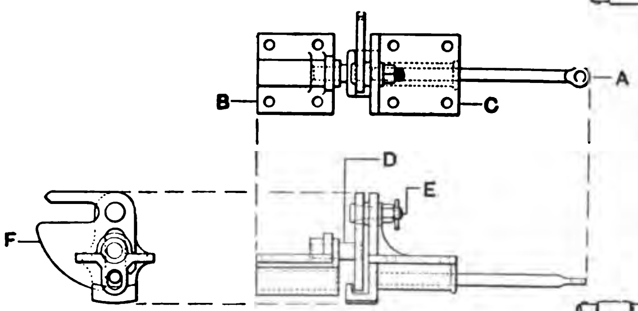
A scotch block (Figs. 1518-1520) is a device for low speed tracks. It consists of a triangular block or iron carried on a swinging arm. The block normally rests on the rail as shown.



Figs. 1580-1582. Tumbler Bridge Lock.

Names of Parts of Tumbler Bridge Lock; Figs. 1580-1582.

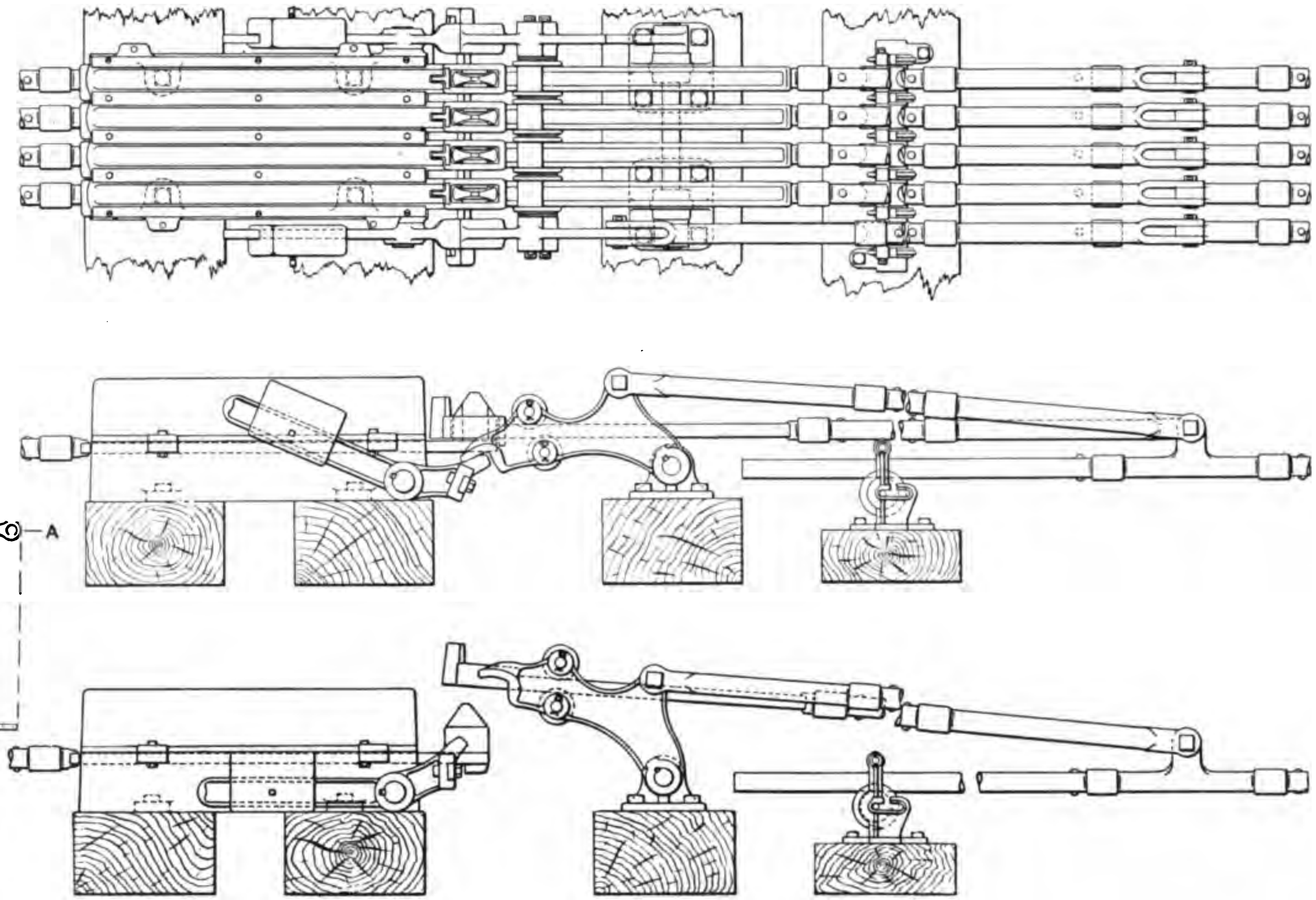
A	*Releasing Stand*	D	*Plunger*
B	*Stud*	E	*Plunger Casting*
C	*Pin*	F	*Locking Tumbler*



Figs. 1583-1585. Gravity Bridge Lock.

Names of Parts of Gravity Bridge Lock; Figs. 1583-1585.

A	*Plunger*	D	*Stud*
B	*Lock Casting*	E	*Stud Bolt*
C	*Plunger Casting*	F	*Escapement Lock*


*Figs. 1586-1588. Multiple Bridge Coupler.

DRAWBRIDGE PROTECTION.

Drawbridge protection by interlocking involves some special devices. Couplers must be provided to make the pipe line continuous from shore to bridge. These consist of hooks and sockets mounted in frames (Figs. 1586-1588). One frame contains a hinged member for raising the sockets from engagement with the hooks. A separate lever may be used to disengage the line or the same lever that unlocks the bridge may be employed. It is not customary to carry wire on the bridge deck. Where wire is used the line is changed to pipe on the bridge (Figs. 1589-1590). Usually clearances on bridges will not permit the use of horizontal compensators, so vertical compensators (Figs. 1606-1609) are used. Safety demands that the bridge be locked in alignment and the rails in place before the signals can be cleared.

Figs. 1580-1582 illustrate a tumbler drawbridge lock for lift bridges. Casting A is carried on the bridge and to it is fastened a stud B fitting in a notch of the locking tumbler F. This tumbler is pivoted on plunger casting F. The stud B raises F when the bridge is closed. When the bridge opens the locking tumbler drops into the slot in front of the plunger, thereby preventing its passage all the way through E. This device acts as a check on the rail lock or the releasing lever as it is necessary for the plunger to pass through E before either of the above can act.

Figs. 1583-1585 illustrate a device for the same purpose as Figs. 1580-1582 applied to a swing bridge. Casting B is fastened to the bridge and casting C to the shore. Escapement lock F is pivoted to C and is engaged by a stud D on B to move it so that the notch comes opposite to the plunger opening when the bridge is closed. When the bridge opens F is moved in front of the plunger and

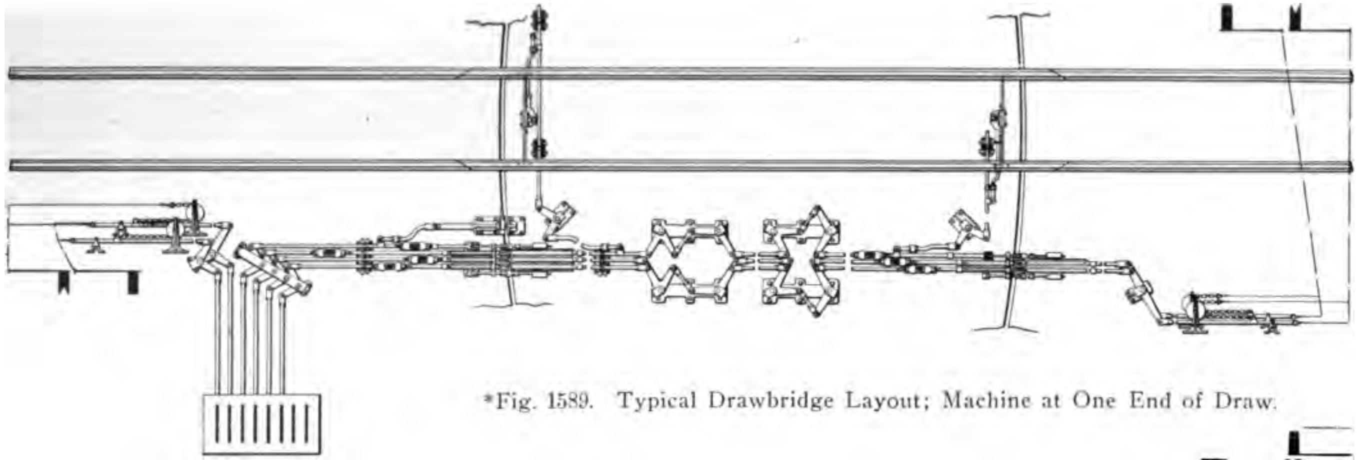


*Fig. 1589. Typical Drawbridge Layout; Machine at One End of Draw.

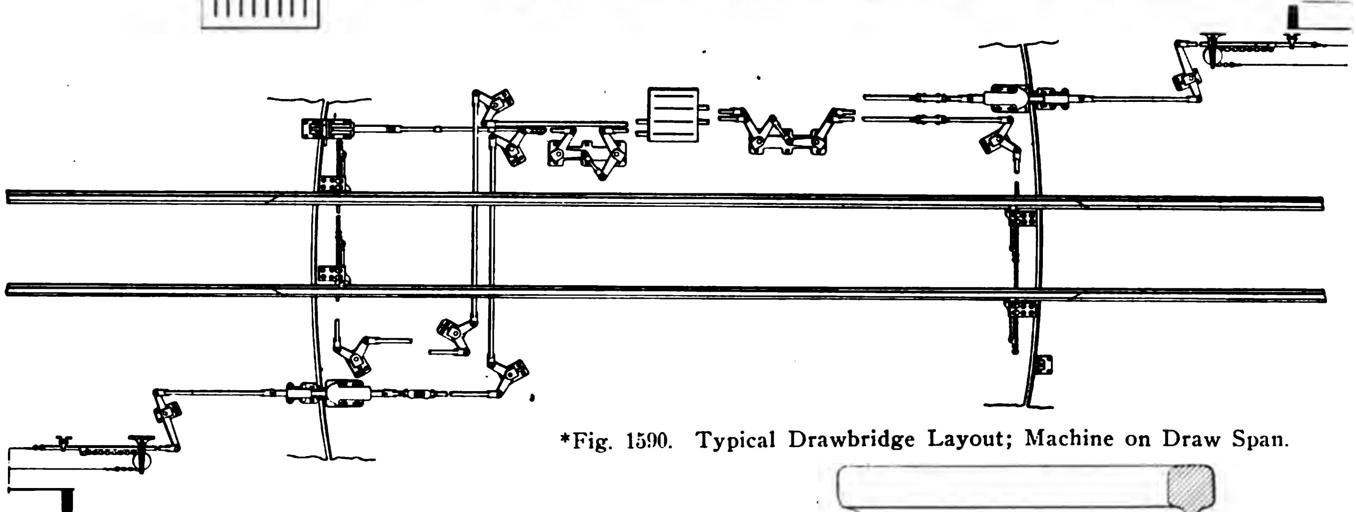


*Fig. 1590. Typical Drawbridge Layout; Machine on Draw Span.

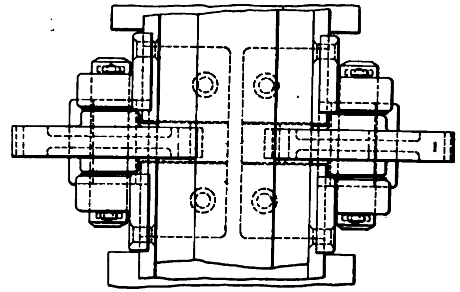


Fig. 1591.

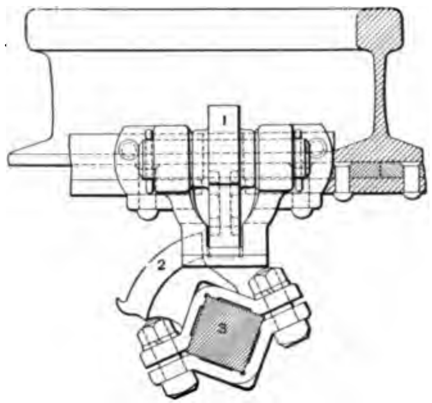


Fig. 1592.

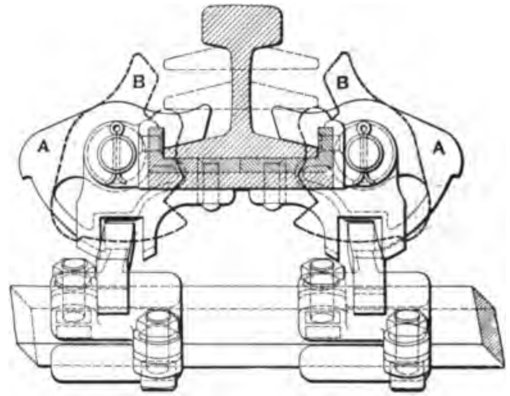
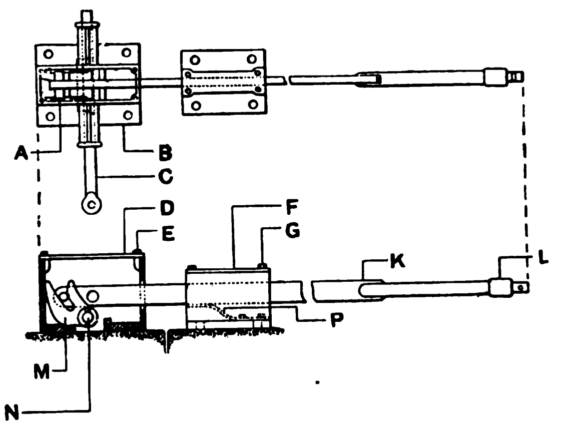


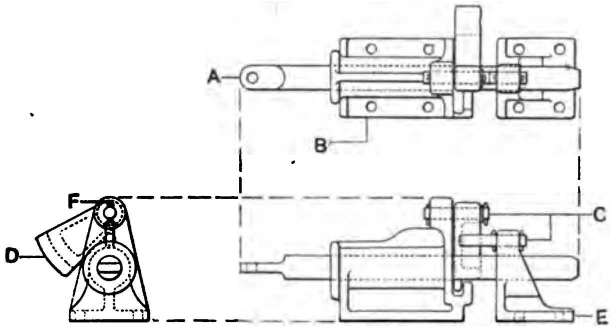
Fig. 1593.

Figs. 1591-1593. The Weaver Drawbridge Rail Lock. T. George Stiles Company.

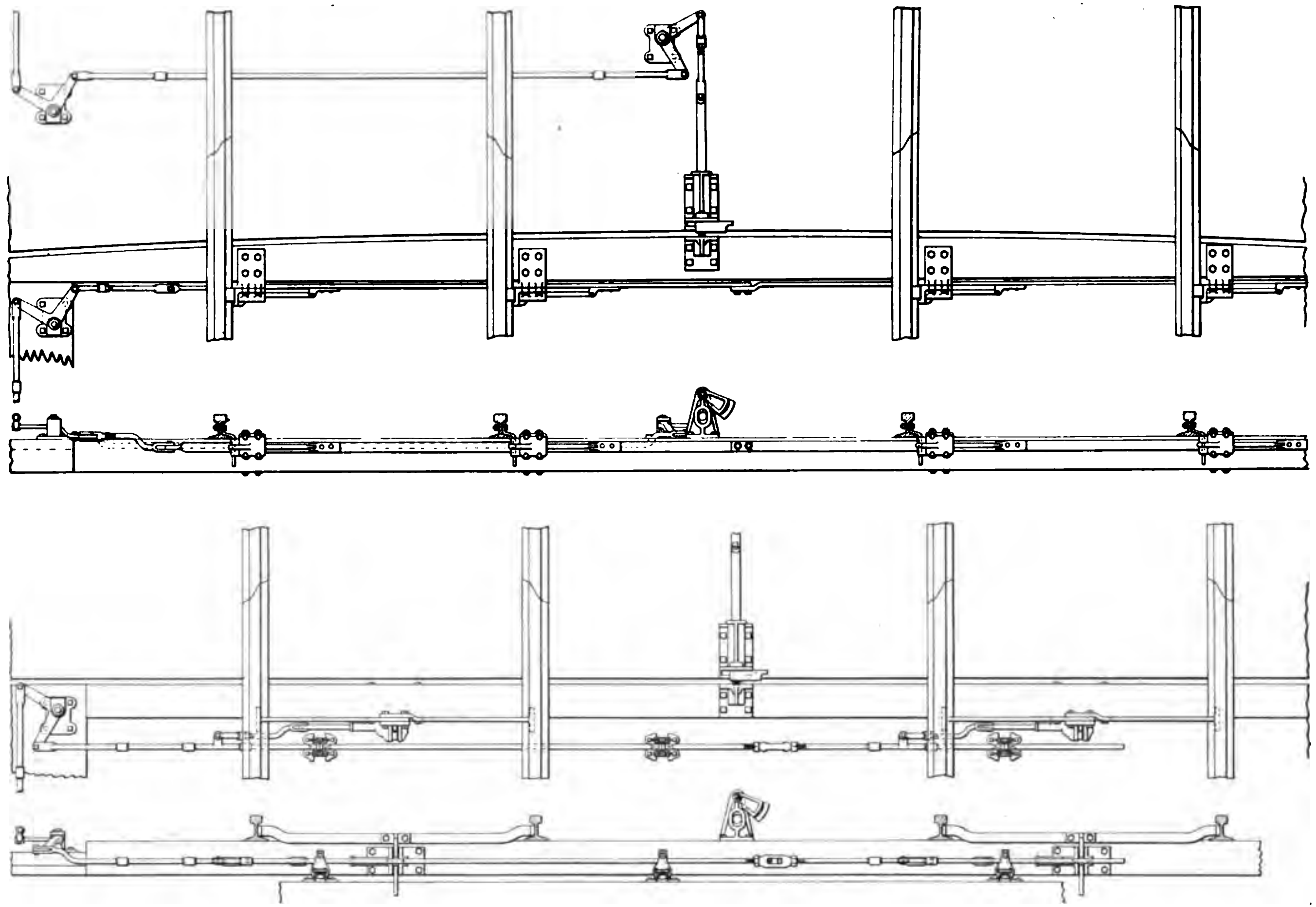
blocks it. Figs. 1596-1598 show a similar device. The plunger here is very heavy and is designed to lock the bridge against movement if desired. The locking block D is moved to one side by a stud on casting E. Figs. 1594-1595 show a device designed for locking swing bridges. Here the tappet K works with the apparatus on the bridge, while the plunger C is operated from the shore and holds the tappet against withdrawal. The tappet is guided by a box and rests on spring P, which absorbs shocks. It carries at its extremity a pin A which engages escapement jaw M, this jaw being pivoted in the plunger box B. When the tappet is withdrawn the stud pulls the escapement jaw in front of the plunger hole where it remains blocking the plunger until the tappet is again inserted. Figs. 1599-1602 show bridge rail locks. They are used to lock the bridge rails in place. They consist of a modification of an inside connected facing point lock. The plunger casting has an opening through which a tongue fastened to the front rod passes. This tongue blocks the plunger when the rails are raised.



Figs. 1594-1595. Bridge Bolt Lock.



Figs. 1596-1598. Gravity Bridge Lock.



*Figs. 1599-1602. Bridge and Rail Locks.

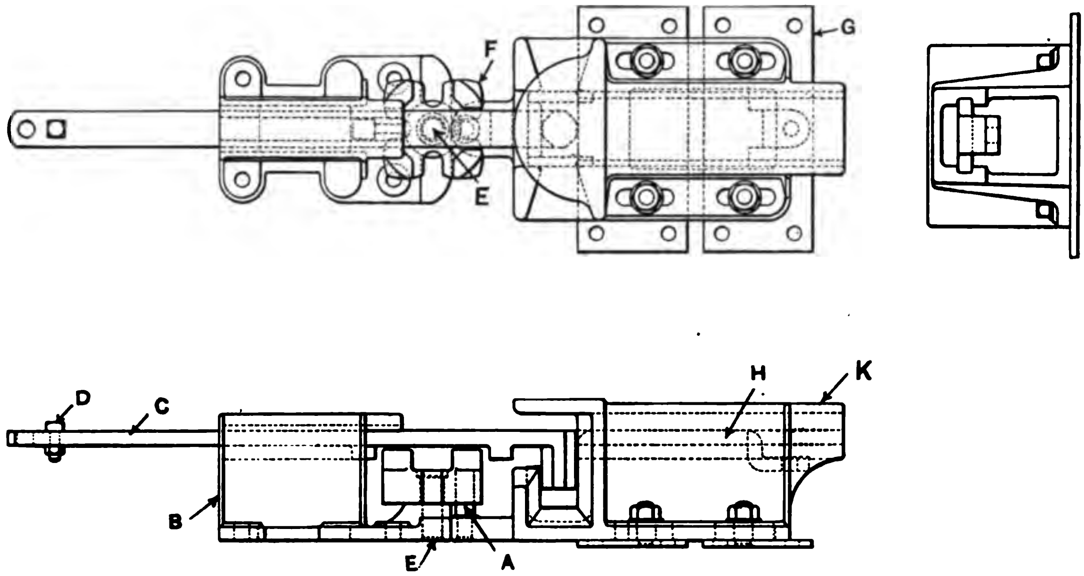
Names of Parts, Gravity Bridge Lock; Figs. 1596-1598.

A *Plunger*
B *Plunger Casting*
C *Pin*
D *Locking Block*
E *Lock Casting*
F *Cotter*

Names of Parts, Bridge Bolt Lock; Figs. 1594-1595.

A *Pin*
B *Plunger Box*
C *Plunger*
D *Plunger Box Cover*
E *Machine Screw*
F *Guide Box Cover*
G *Machine Screw*
K *Tappet*
L *Pipe Sleeve*
M *Escapement Jaw*
N *Pin*
P *Spring*

Figs. 1591-1593 show another type of rail lock. The rail dogs 1 (Figs. 1591-1592) normally occupy the position A (Fig. 1593). When unlocked the dogs allow themselves to be raised by the lifting of the rail to the position B, locking the lug 2 and rocker shaft 3 in the reverse position. When the rail is again lowered it restores the dogs to their normal position, allowing 2 and 3 to revolve and securely lock the rail in place. An automatic bridge coupler for swing bridges is shown in Figs. 1603-1605. Casting K is mounted on the bridge and casting B on the abutment. K is provided with slotted bolt holes for adjustment. On B is mounted a spider F, which revolves on a stud E through its center. It is provided with four dogs on its upper surface and has four notches in its circumference between the dogs. The pin A on K engages in one of the notches and holds the spider in position shown when the bridge is closed. When the bridge is opened the pin moves the spider through an angle of 45 degrees. In this position two of the dogs on the spider engage the two dogs on the lower surface of hook bar C which forms the shore end of the pipe line. Engaging slide H forms the bridge end of the pipe line; its end is bent as shown and engages the end of the hook bar. This makes the pipe line continuous from shore to bridge. Figs. 1589-1590 and 1599-1602 show applications of some of the apparatus just described.



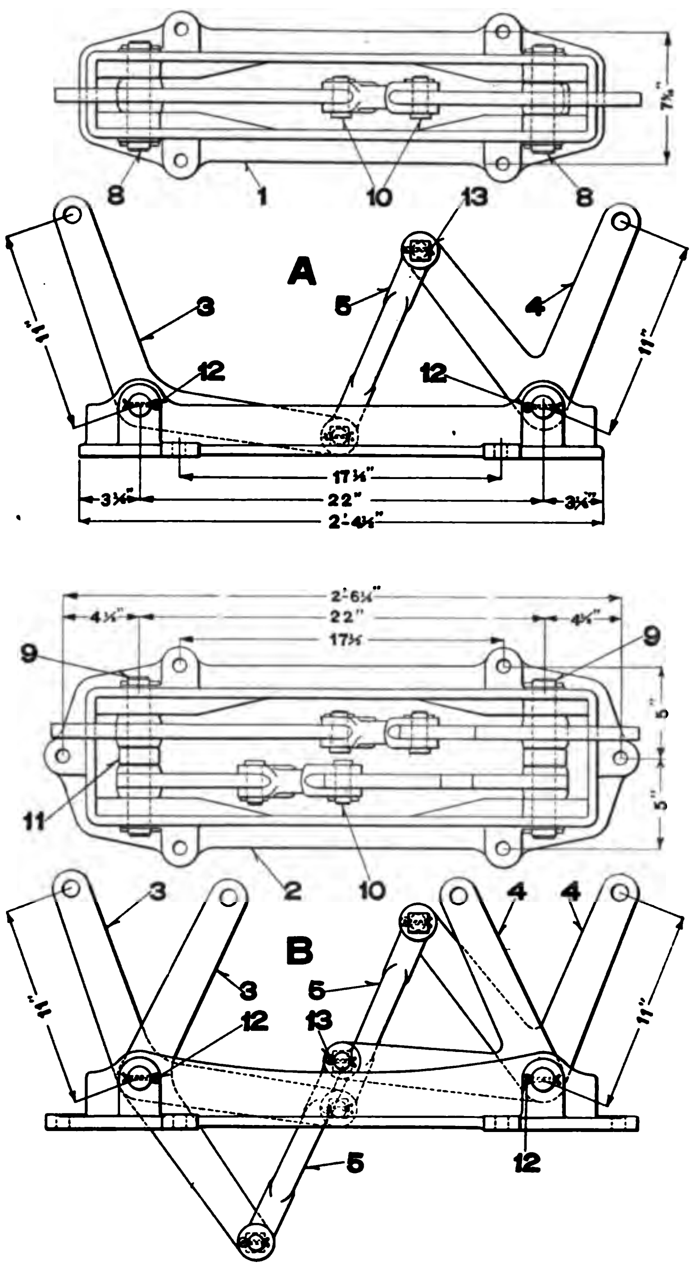
Figs. 1603-1605. Automatic Bridge Coupler.

Names of Parts, Automatic Bridge Coupler; Figs. 1603-1605.

A *Stud*
B *Abutment Casting and Guide*
C *Hook Bar*
D *Stop Bolt*
E *Stud*
F *Spider*
G *Base Plate*
H *Engaging Slide*
K *Coupler Casting*

Names of Parts, Vertical Lazy Jack Compensators; Figs. 1606-1609.

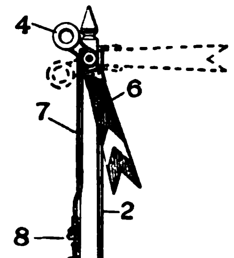
A *One-Way Vertical Lazy Jack Compensator*
B *Two-Way Vertical Lazy Jack Compensator*
1 *One-Way Stand*
2 *Two-Way Stand*
3 11" x 11" *Obtuse Angle Crank*
4 11" x 11" *Acute Angle Crank*
5 *Connecting Link*
8 *Center Pin for* **A**
9 *Center Pin for* **B**
10 *Jaw Pin*
11 *Spacing Washer*
12 *Cotter*
13 *Cotter*

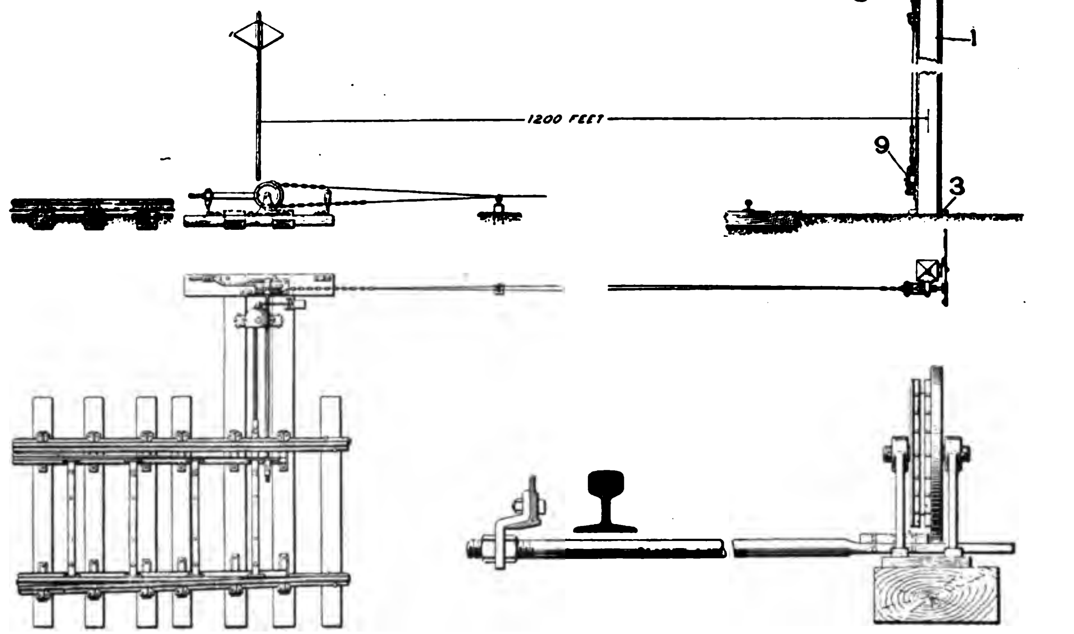


*Figs. 1606-1609. Vertical Lazy Jack Pipe Compensators.

Names of Parts of Distant Switch Signal; Figs. 1610-1612.

1	*Wooden Post*	6	*Blade*
2	*Ladder*	7	*Up and Down Rod*
3	*Ladder Foundation*	8	*Balance Lever and Stand*
4	*Spectacle*	9	*Signal Wheel and Stand*





Figs. 1610-1612. Distant Switch Signal, Wire Connected and Operated by Ground Lever with Rim Lock. Union Switch & Signal Company.

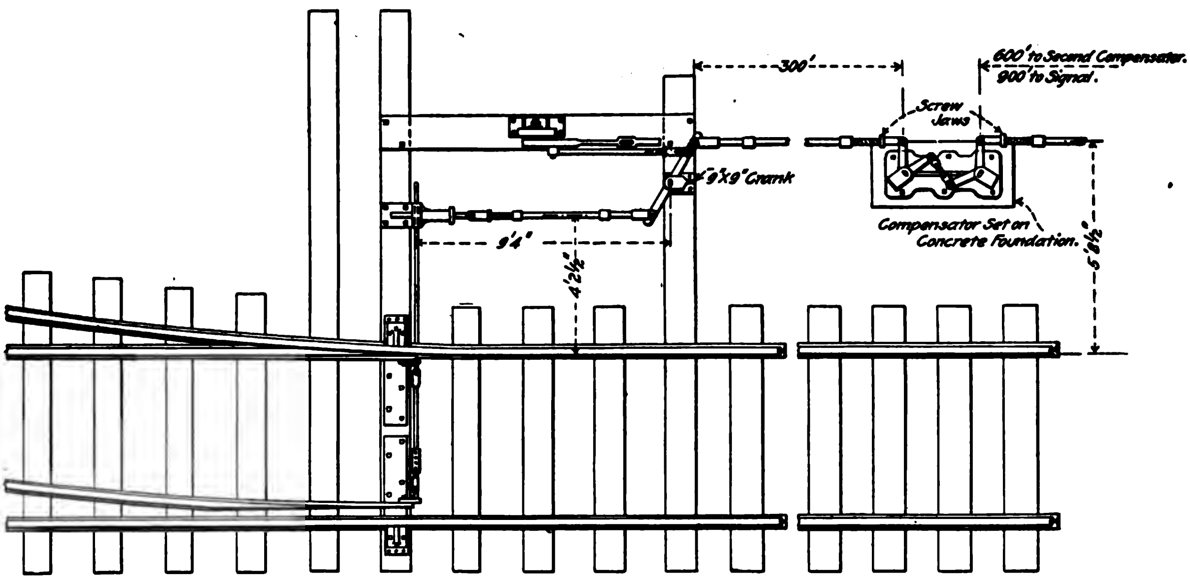


Fig. 1613. Layout for Pipe Connected Distant Switch Signal and Facing Point Lock. New York, Ontario & Western.

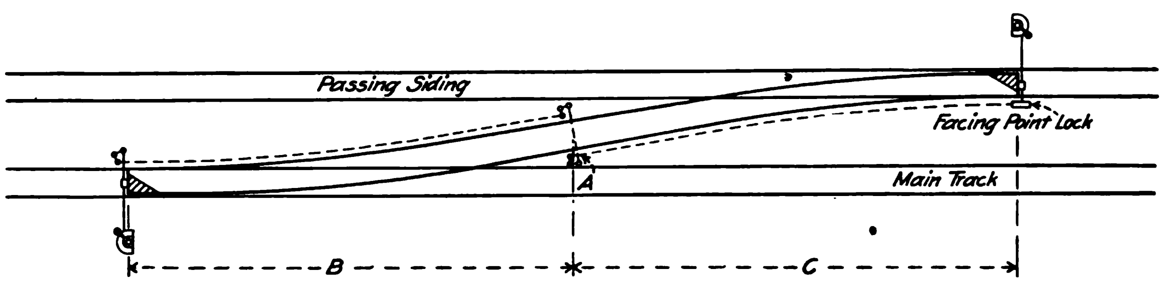
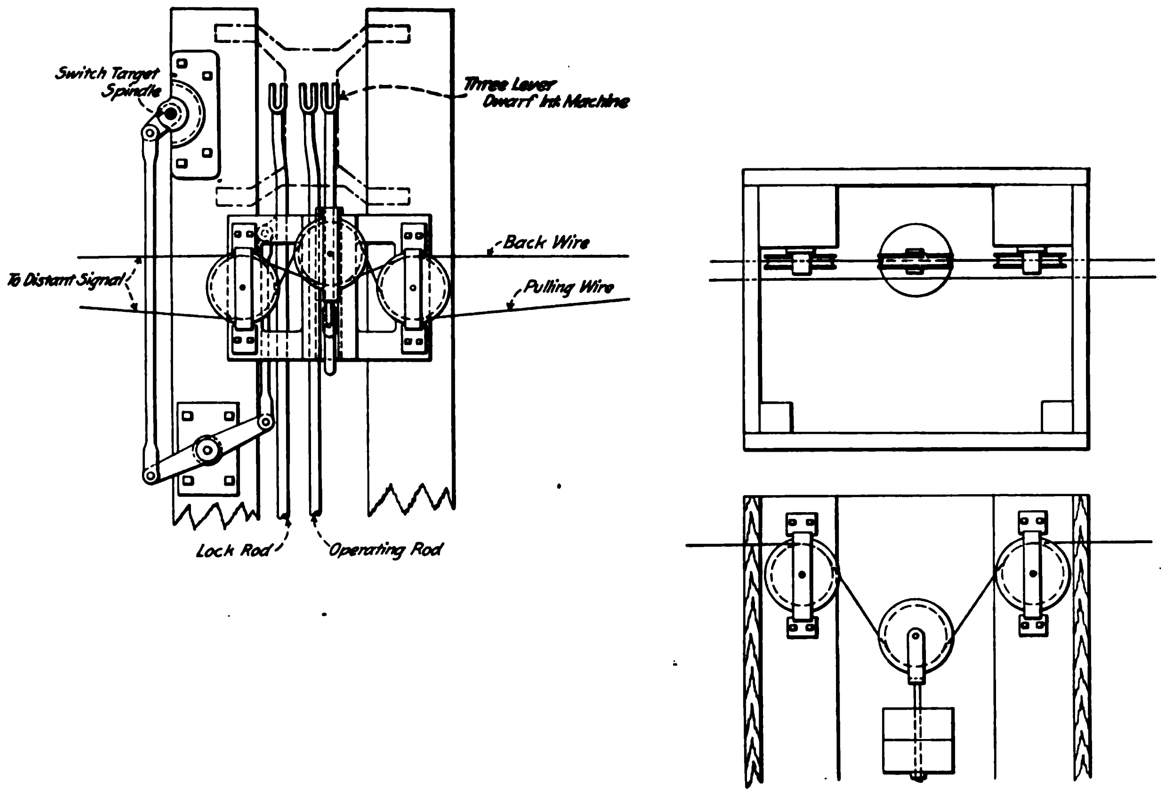
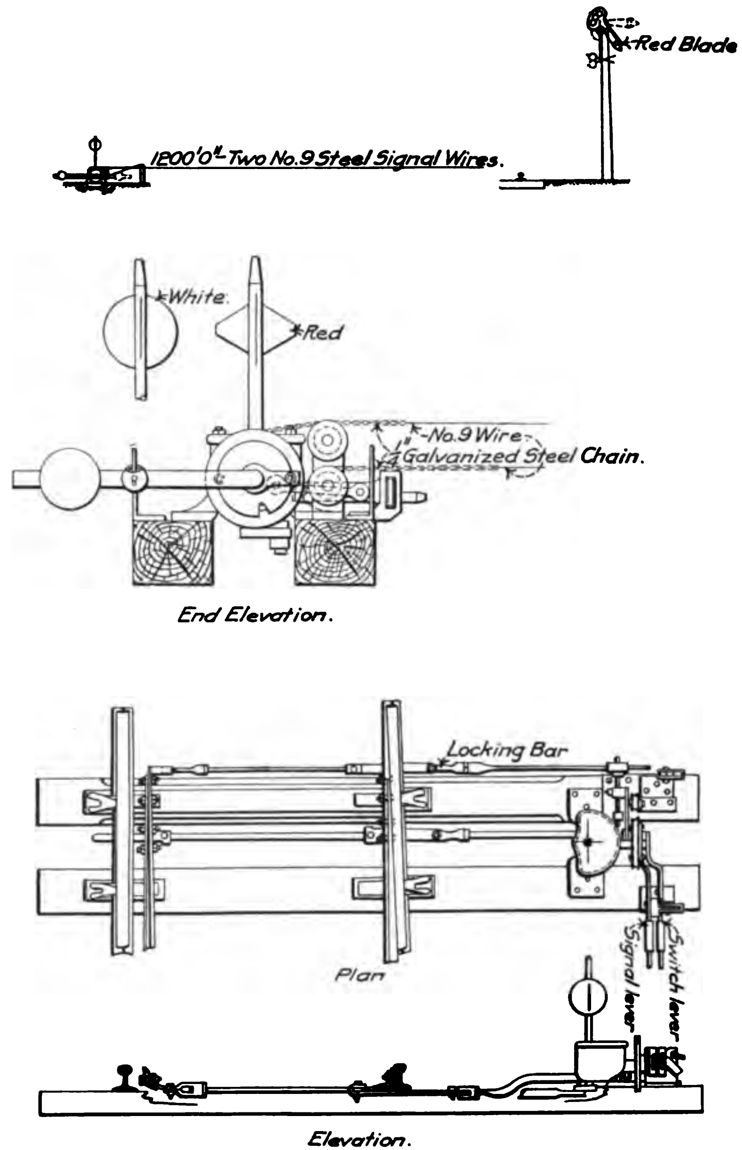


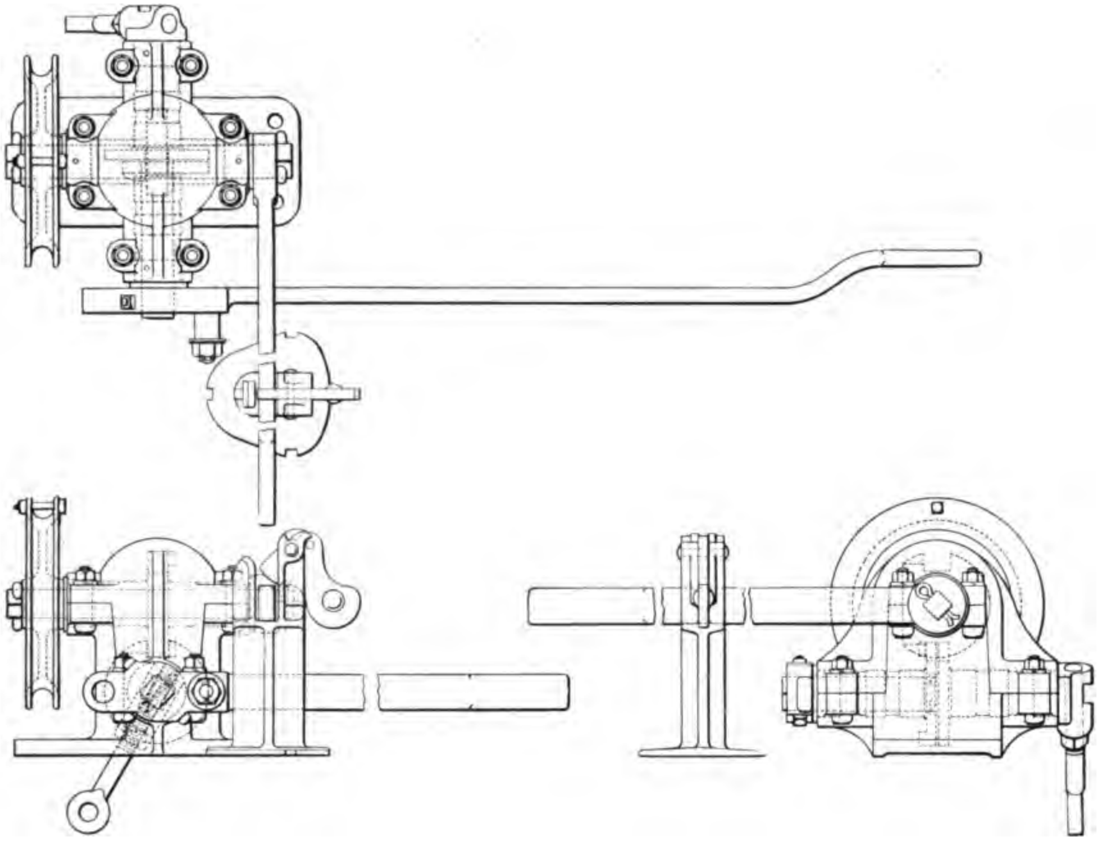
Fig. 1614. Self-Compensating Pipe Run for Pipe Connected Crossover. Michigan Central.



Figs. 1615-1617. One Signal Operated from Two Switches; Details of Construction. Nashville, Chattanooga & St. Louis.

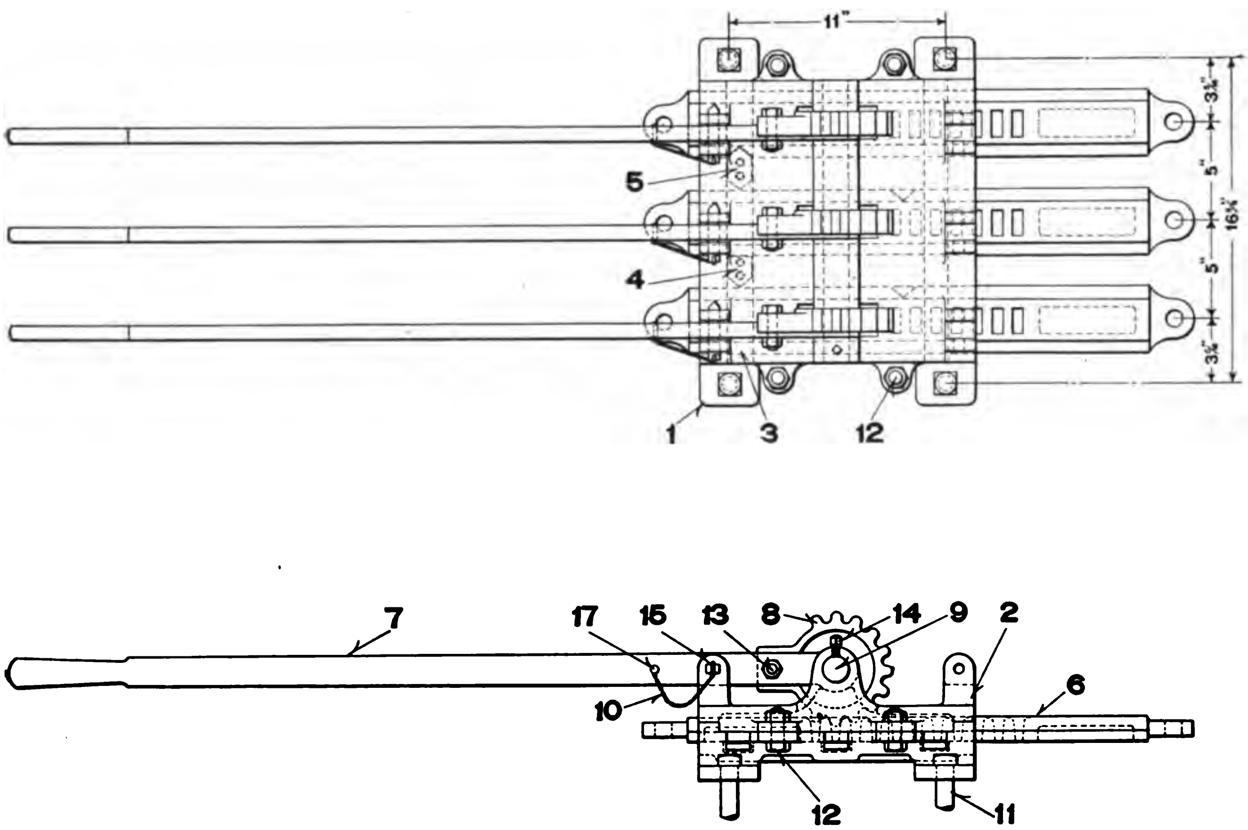


Figs. 1618-1622. Layout and Detail of Distant Switch Signal and Facing Point Lock, Operated by Double Lever Switch Stand. New York Central & Hudson River.

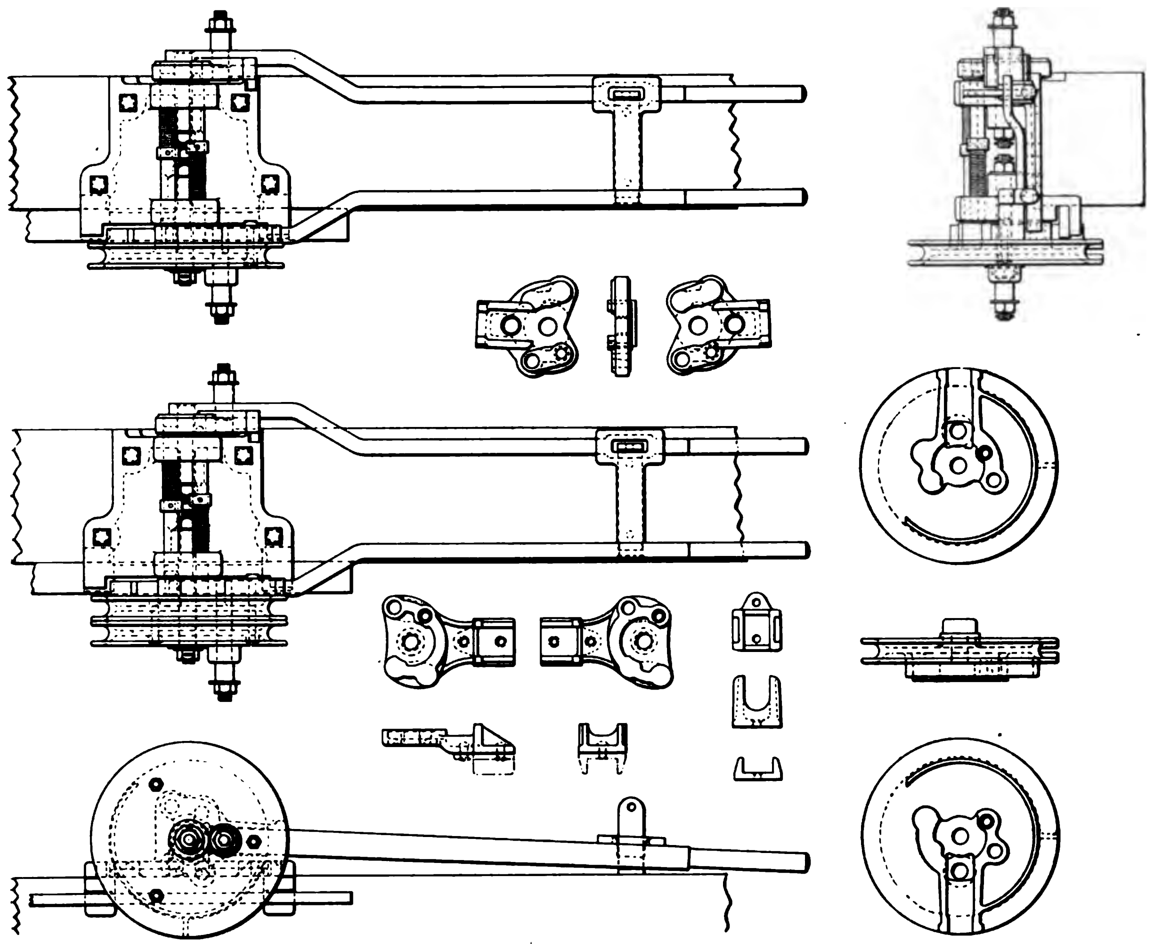


Figs. 1623-1625. Double Ground Lever Interlocking Stand, with Disk Locking. The Union Switch & Signal Company.

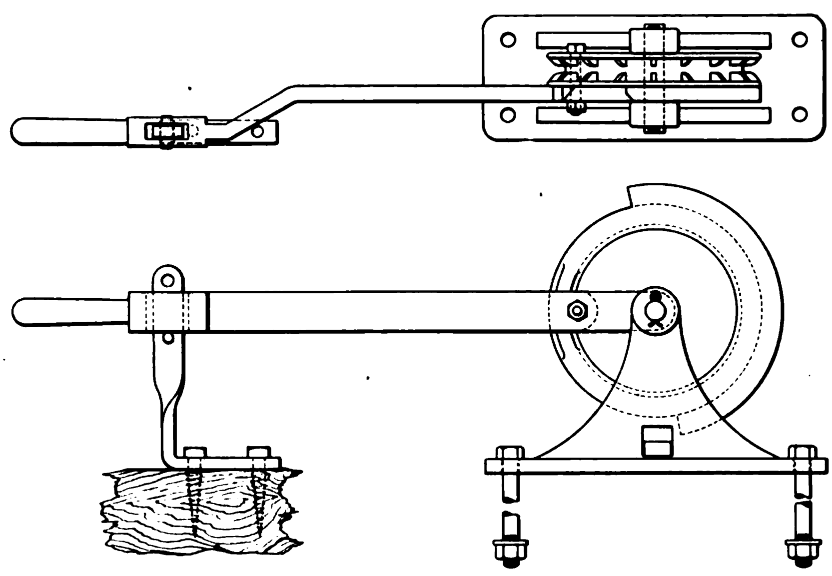
Numbers Refer to List of Names of Parts on Opposite Page.



Figs. 1626-1627. Triple Ground Lever Interlocking Stand. The Union Switch & Signal Company.



Figs. 1628-1638. Double Ground Lever Interlocking Stand. The Union Switch & Signal Company.



Figs. 1639-1640. Rim Lock Ground Lever Interlocking Stand. The Union Switch & Signal Company.

Names of Parts, Triple Ground Lever Interlocking Stand; Figs. 1626-1627.

1	*Base*	5	*Dog*	9	*Shaft*	13	*Bolt*
2	*Cap*	6	*Rack*	10	*Chain*	14	*Set Screw*
3	*Dog*	7	*Lever*	11	*Bolt*	15	*Locking Pin*
4	*Dog*	8	*Pinion*	12	*Bolt*	17	*Rivet*

POWER INTERLOCKING.

The earliest system of interlocking employed and that now in most general use is the so-called mechanical interlocking (Figs. 661-1609) in which the switches and signals are manually operated by means of interlocked levers connected with them by iron or steel pipe lines or by wire. Experience has shown that in order to secure a reasonable degree of safety, it is essential that the following requirements be met:

All derails, movable frogs, locks, switches and home signals should be worked by pipe; signals worked by wire should have two wires, front and back; all pipe and wire lines should be automatically compensated for changes in temperature; all derails, movable frogs and facing point switches should be provided with duplex facing point locks, so arranged that the normal plunger cannot lock the switch reversed, and vice versa; all cranks and pipe compensators should be fixed on rigid foundations set in best quality concrete; no facing point switch more than 600 feet from the cabin should be taken into the system; no lever should be overloaded by putting on it such a number of switches or bars as to prevent a man of average strength from throwing it with one hand.

The fatigue incident to working mechanical levers at a busy plant is often severe, so that if the plant is large, it is sometimes necessary to employ as many as eight men on each of three shifts of eight hours each. Moreover, under certain conditions it is costly to operate such a plant. Where the distance between the extreme switches to be operated is over 1,600 ft. it is generally necessary to provide two mechanical interlocking cabins.

To overcome these and other disadvantages power interlocking has been devised in which the various functions are worked by air under pressure, by electricity or by a combination of the two. With power, switches and signals can be worked at any desired distance from the cabin; the apparatus being so safeguarded that switches must actually be moved and securely locked in the proper position before a signal governing movements over them can be cleared. Each signal, when cleared, automatically locks the lever operating it in such manner as to prevent the release of levers controlling conflicting signals and switches until such signal has been again completely moved to the stop position, thus effectually providing against the simultaneous display of two conflicting clear signals. There being no moving parts between cabin and switches and signals, wear of mechanism, lost motion and the troublesome effects of expansion and contraction of metal connections are eliminated. Much less room is required for leadout connections than in a mechanical plant, valuable space thus being saved. Cabins may be much smaller and of lighter design. The operation at the machine requires so little physical exertion that one man can do an amount of work that in a mechanical plant would require three or four.

ELECTRIC INTERLOCKING.

GENERAL RAILWAY SIGNAL COMPANY.

In this system switches and signals are operated by electric motors, the current to actuate them being usually furnished by a storage battery charged from a dynamo driven by an electric motor or a gas engine. Control of the various functions is effected through an interlocking machine.

A general view of the electric interlocking machine known as Model 2 as it appears when assembled and installed is shown in Fig. 1641. This model is equipped with vertical locking of the Johnson Type (Figs. 775-801), but reduced in size, and in proportion to the number of levers, occupies but a small amount of floor space in the tower. The release locking or "indication" (see definition) is effected by an electro-magnetic device located immediately below each interlocking lever, these magnets being energized by a dynamic current furnished by the switch or signal motor controlled by that lever; the arrangement is such, however, that this cannot occur until a switch has moved to a position corresponding with that of the lever and is properly locked in that position, or when a signal arm has assumed the full horizontal position. Precautions are taken in both circuits and mechanical arrangement to prevent crosses in circuits from resulting in the improper movement of a switch or in a signal giving a false "proceed" indication.

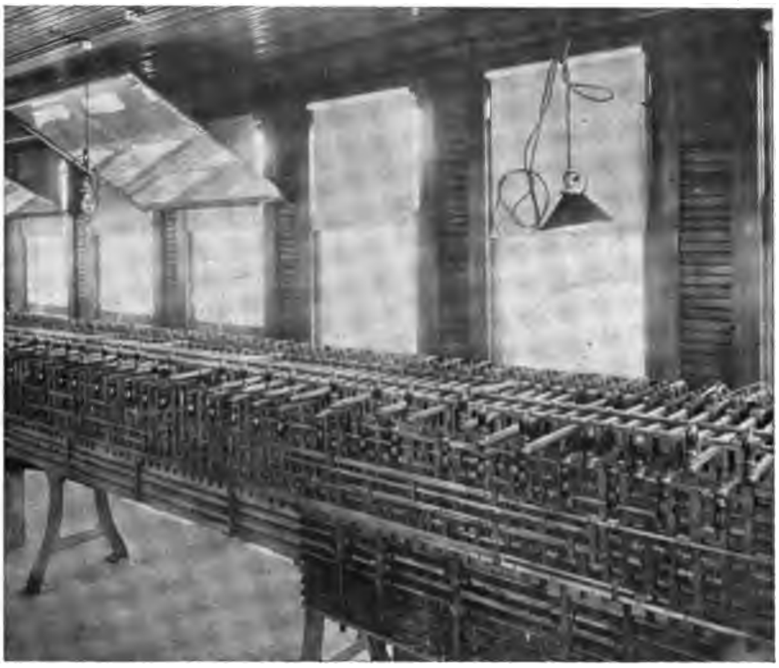


Fig. 1641. Electric Interlocking Machine. General Railway Signal Company.

A switch failing to complete its movement owing to some obstruction in the switch point, or for any other cause, may be restored to its original position, and the lever operated back and forth, thus frequently dislodging the obstruction, and preventing failure and incidental detentions.

Three views of a standard Model 2 interlocking machine are shown in Figs. 1642-1644, a rear view showing the terminal and fuse board shown in Fig. 1642, an end view in Fig. 1643, and a front view showing the locking in Fig. 1644. This machine in general consists of the frame work, the case H, the terminal and fuse board A, the locking G and the levers with their guides E, controller C, and magnets I and S. The frame work is made in three styles, depending upon the numbers of levers or sections and the amount of locking. For machines not exceeding one and one-half sections the form of construction shown in Fig. 1645 is employed. For machines exceeding one and one-half sections and having a moderate amount of locking the design shown in Fig. 1641 is used, two or more legs being necessary to support the mechanism. For machines having a great amount of locking,

Names of Parts, Figs. 1641-1644.

A *Terminal Board*
B *Controller Frame*
C *Circuit Controller*
D *Lever*
E *Lever Frame*
F *Lever Handle*
G *Locking Frame*
H *Case*
I *Indication Magnet*
K *Bus Bars*
L *Supports*
M *Fuse*
N *Indication Selector*
O *Leg*
P *Bottom Frame*
Q *Binding Posts*
R *Connecting Bar*
S *Safety Magnet*

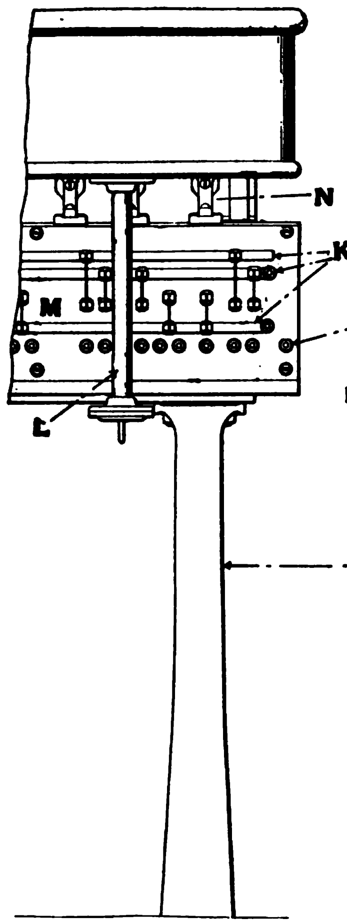


Fig. 1642. Rear of Electric Interlocking Machine.

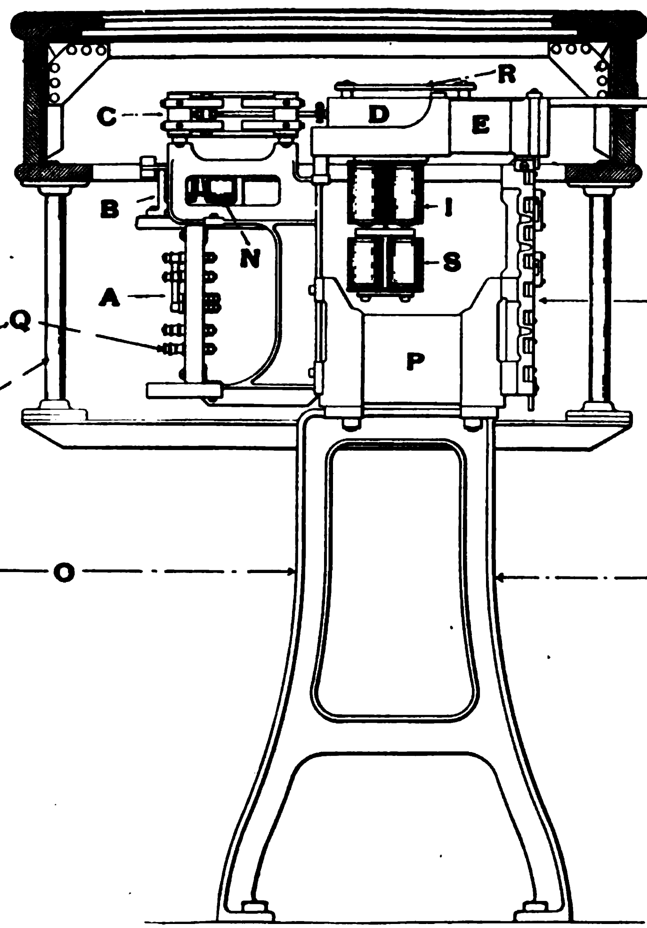


Fig. 1643. Section of Electric Interlocking Machine.

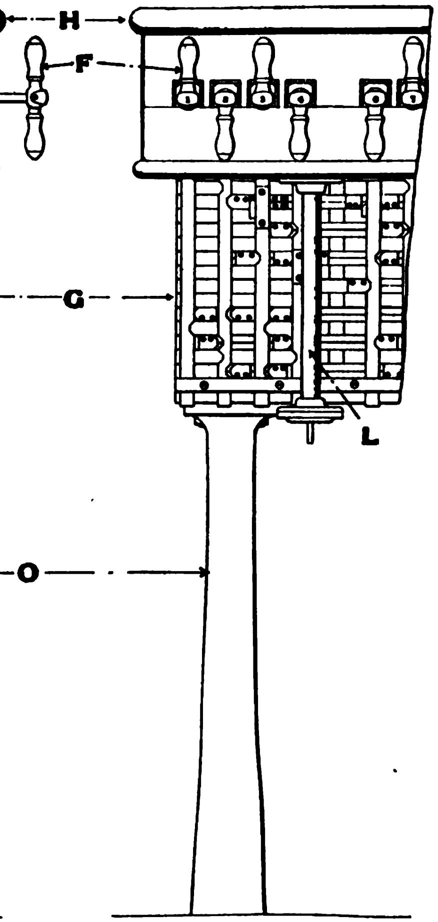


Fig. 1644. Front of Electric Interlocking Machine.

plates may be added to supply the number of tiers necessary. The case H is intended to enclose the controllers and levers only, leaving the terminal board and locking exposed. Glass covers on the top permit access to all enclosed parts. These covers may be sealed or locked if desired to prevent tampering with the indication mechanism.

The terminal and fuse board is the place where all wires terminate and where the various circuits are fused. It consists of a slate slab with three bus bars, the upper bus bar being the one which supplies current to operate switches, the lower one signals, and the middle, the indication bus bar common to all switches and signals. The various incoming wires, including those from the battery and magnets and also wires from the circuit controllers in the machine, terminate on the binding posts or fuse posts, as the case may be, which are mounted upon the board as shown. The terminals and fuses for each lever are directly under it and numbered and lettered to correspond. The arrangement is such that any wire or other electrical part may be conveniently disconnected for testing purposes. The connecting wires running from the terminal board to the various controllers are made up in sets formed to fit and taped together.

Figs. 1646-1648 show the details of controllers and indication selectors. A view of the levers and controllers when assembled with magnets is shown in Figs. 1649-1650. The lever, which slides in its guide, is held in place by screws as shown in Fig. 1649, is provided with a cam slot U, which gives the necessary motion to the tappet V, to operate the locking. The dotted circles 1 to 5 in the cam slot, indicate the position of the tappet roller which corresponds with like numbered positions of contact block Z. The lever is connected to the contact block by the rod W, the contact block being thereby forced to move with the lever and to assume the positions 1 to 5. In passing from position 1 to 2 the tappet V is raised, thus locking all conflicting levers before any

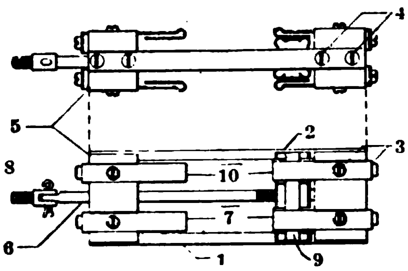
Fig. 1645. Small Electric Interlocking Machine.

change in circuit control is made. The method by which a switch lever is prevented from completing its stroke until the function controlled by such lever has assumed a position corresopnding therewith will be understood by the following changes which take effect as the lever is moved through its complete stroke. In Figs. 1649-1650, G shows the lever normal and H shows it resting against the indication stop (position 4). In passing from position 1 to 2, the projection M on lever D coming against projection K on latch L causes the latch to assume the reverse position as shown in H, bringing projection J into the path of tooth Q. In moving from position 2 to 3 the tooth Q, coming in contact with a similar projection on the cam N, causes it to revolve into the horizontal position, shown dotted in H, thus forcing dog P into the position shown in H and locking latch L in its horizontal position. In moving from position 3 to position 4 the cam N is revolved into the position shown by full lines in H and the lever is stopped at position 4 by the tooth Q coming against projection J. Meanwhile the contact block Z having come into contact with brushes X-X complete the battery circuit to the motor causing the switch to be operated and locked in position. The indication current is then sent through magnet I, lifting armature T and causing plunger R to strike dog P and throw it out from under latch L. The latch being thus released, drops to its normal position shown in G, and permits lever movement from 4 to 5, thus completing the stroke, and, by lifting tappet V, releasing all levers which do not conflict with the new position of switch. The stroke from reverse to normal acts in the same way.

Signal levers also operate in the same manner with the exception that on the *reverse* stroke, when contact block Z is in position 4, the current is sent through magnet 1 from the battery, releasing the lever and allowing it to pass to position 5, the *normal* indication being the only one considered necessary.

The safety magnet S is placed beneath the indication magnet I, the indication armature resting normally upon the pole pieces of the safety magnet. All current flowing from battery to the control wires passes through this safety magnet. This is so arranged that a cross between two wires would cause both the current flowing through the switch motor and that flowing through the indication magnet to flow through the safety coils, so that if the whole current came back through the indication coils the current could not exceed that flowing through the safety magnet; and since the armature rests upon the safety magnet and is one-quarter of an inch away from the indication magnet, the latter cannot lift the armature. The safety coils being connected in series, a break in any of the wires concerned would cut off the current from the function.

Fig. 1665 shows diagrammatically a switch, a two-arm home signal, a distant signal, a dwarf signal, the generator, battery, power switchboard, operating switchboard, interlocking machine, circuit controllers, indicating mechanism, switch and signal motors, etc., and wiring for same. The switchboards shown may be considered as typical of those usually installed; a generator with suitable driving power and storage battery of proper capacity being required to supply the energy necessary for the operation of the plant. The power board is used to regulate and safeguard the circuit from the generator to the operating board, and the latter to distribute and protect the circuits to the interlocking machine



Figs. 1646-1647. Switch Controller.

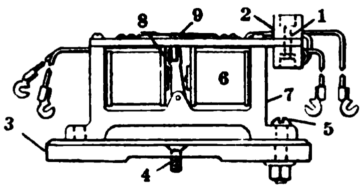
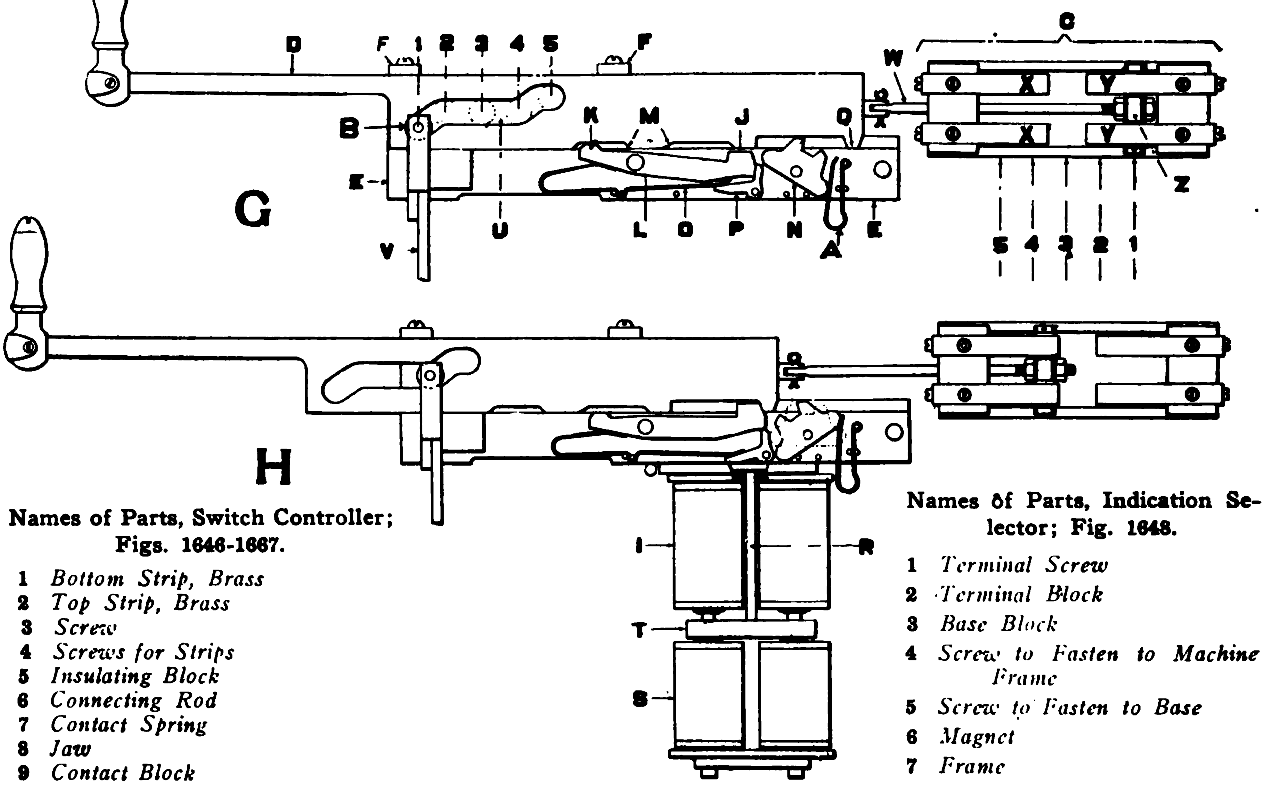


Fig. 1648. Indication Selector.

Letters and Numbers Refer to List of Names of Parts on Following Page.



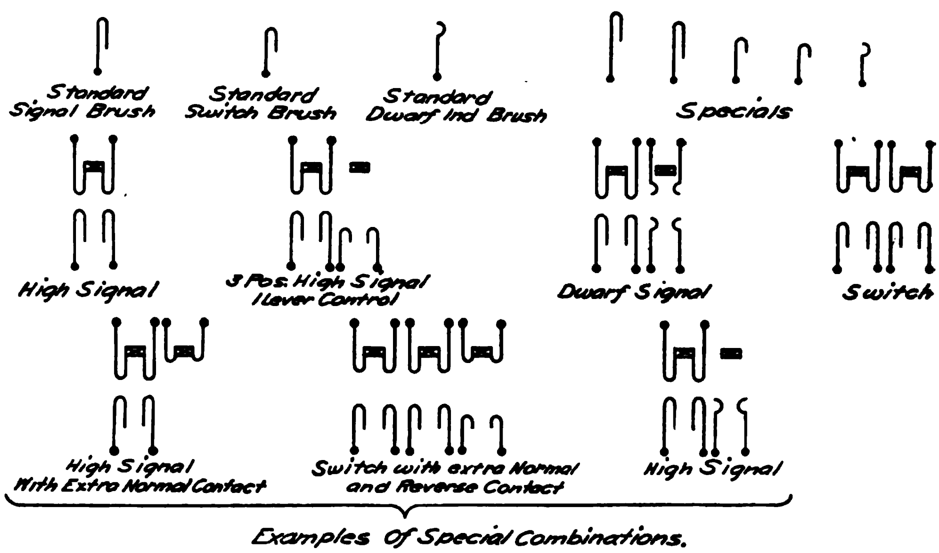
Figs. 1649-1650. Details of Lever.

Names of Parts, Switch Controller; Figs. 1646-1667.

1 *Bottom Strip, Brass*
2 *Top Strip, Brass*
3 *Screw*
4 *Screws for Strips*
5 *Insulating Block*
6 *Connecting Rod*
7 *Contact Spring*
8 *Jaw*
9 *Contact Block*
10 *Contact Spring*

Names of Parts, Indication Selector; Fig. 1648.

1 *Terminal Screw*
2 *Terminal Block*
3 *Base Block*
4 *Screw to Fasten to Machine Frame*
5 *Screw to Fasten to Base*
6 *Magnet*
7 *Frame*
8 *Armature with Contact*
9 *Contact Spring*



Figs. 1651-1664. Symbols Used in Circuit Diagrams for Electric Interlocking. General Railway Signal Company.

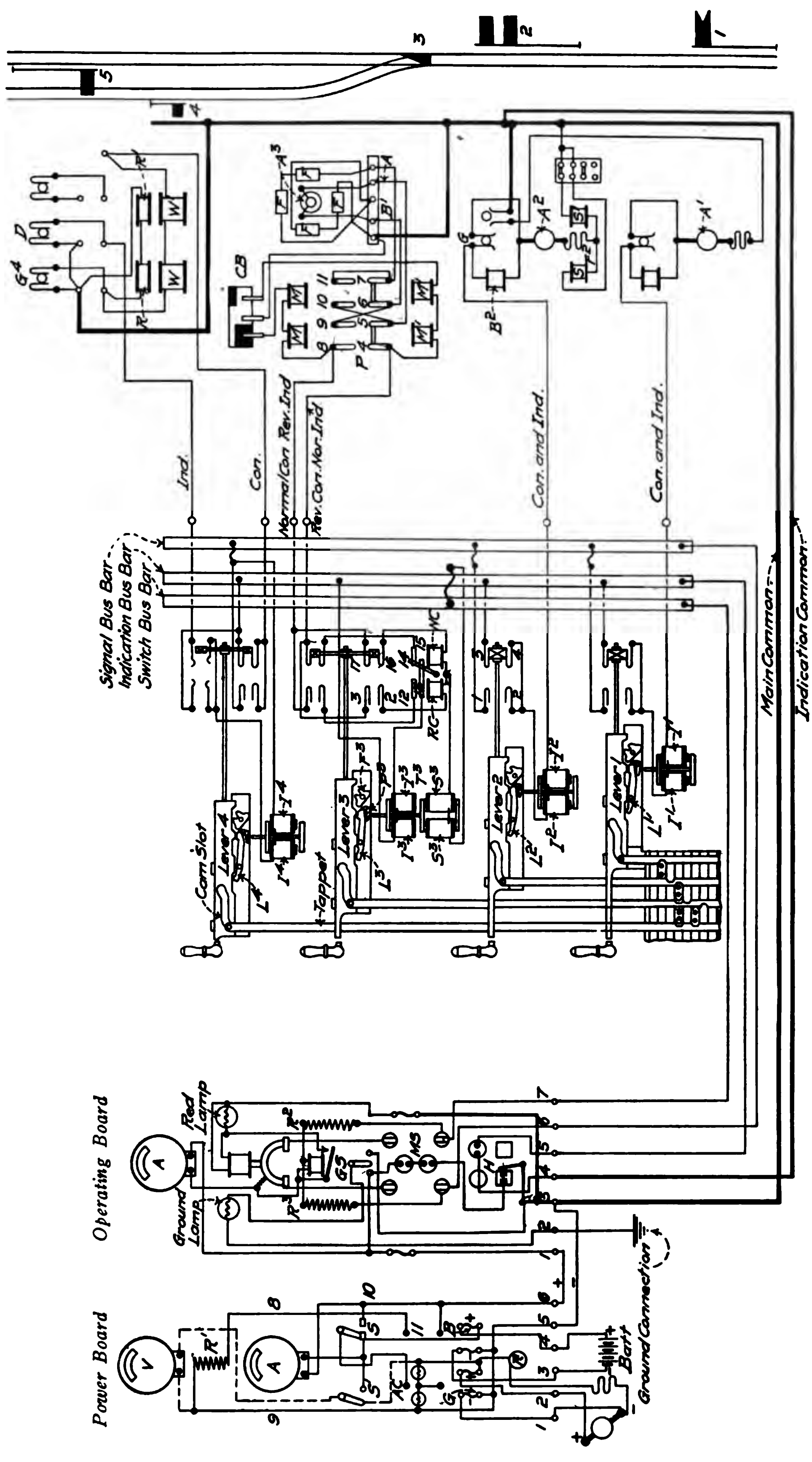


Fig. 1665. Typical Circuits for Electric Interlocking.

List of Names of Parts of Lever Latching and Indicating Mechanism; Figs. 1648-1649.

A *Cam Spring*	**F** *Cap*	**P** *Indication Dog*	**V** *Tappet*
B *Tappet Roller*	**I** *Indication Magnet*	**R** *Indication Plunger*	**W** *Connecting Rod*
C *Circuit Controller*	**L** *Latch*	**S** *Safety Magnet*	**X** *Reverse Contact Springs*
D *Lever*	**N** *Cam*	**T** *Indication Armature*	**Y** *Normal Contact Springs*
E *Lever Frame*	**O** *Latch Spring*	**U** *Cam Slot*	**Z** *Contact Block*

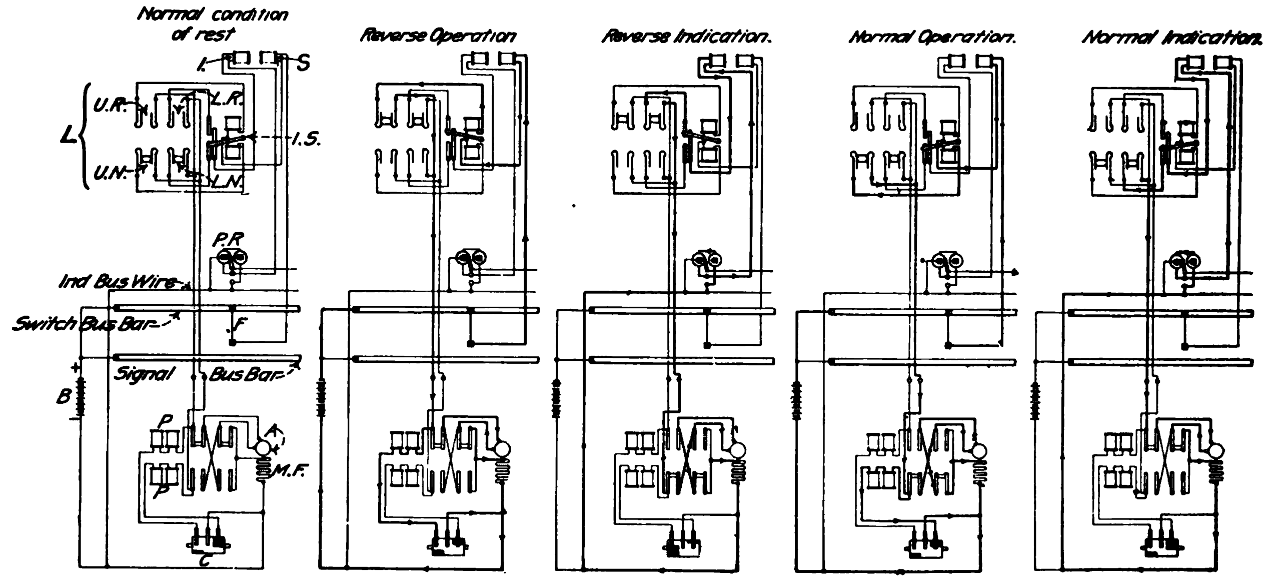


Fig. 1666. Fig. 1667. Fig. 1668. Fig. 1669. Fig. 1670.

Diagram Showing Successive Stages in Operation of Electric Switch Control Apparatus.

and the apparatus. The circuits are as follows: From the generator, energy is conducted through binding post 2 of the power board, through the fuse, rheostat R and field coils to the negative side of generator; the rheostat providing variable resistance, the flow of current is regulated so that the proper amount of energy is delivered to battery, taking the following path: From positive side of generator, binding post 2, fuse, one coil and blade of automatic circuit breaker AC, switch S, fuse B+, binding post 4, through the battery, binding post 3, fuse B—, fuse G—, binding post 1, to negative side of generator. Part of the current from the generator passes through both coils of the automatic circuit breaker in series. This holds the circuit breaker closed when current is flowing. This circuit breaker can be arranged to open at any predetermined load or by a reversal of current. The voltmeter V is connected across the terminals of the circuit breaker and when switch S′ is in position shown it registers the voltage of the generator. When S′ is reversed the voltmeter registers the voltage of the battery. Switch S is provided to control the paths of current to battery and interlocking machine respectively. Another switch 11 is provided which, when closed, will throw current from the generator directly onto the operating board through resistance R′.

Energy is delivered to the operating board from post 6 of power board to binding post 1, thence through fuse, to coils of circuit breaker MS, points of polarized relay H to binding post 3 and common (thus holding circuit breaker closed), also from the fuse to the ammeter, through contacts of circuit breaker relay. From the circuit breaker relay the path is divided, one path leading to binding post 7 and the switch operating bus bar, and the other to binding post 6 and the signal bus bar, both passing through contacts of the circuit breaker MS. The resistance coils marked R^2 and R^3 will allow enough current to pass through the circuit to hold several signals in clear position and switches locked, but not to operate any function, the main path being through the contacts of the circuit breaker to posts 7 and 6, thence to the operating bus bars of the machine.

The indication current enters the operating board from the indication common wire at binding post 4 passing through coil of polarized relay to binding post 5 and to the indication bus bar. A cross between an indication wire and any operating wire would reverse the position of this relay, thus causing the circuit breaker MS to open. The attempted operation of any function after circuit breaker has opened will cause the circuit breaker relay to operate thereby lighting a red lamp which gives an indication of the trouble. For with the circuit breaker open current would pass through coils of the actuating relay directly above the ground switch GS, and the resistance R^2 R^3 to the functions. This would pick up the actuating relay closing a circuit through its point to the coils of the circuit breaker relay and the red lamp in multiple to common. The circuit breaker relay would pick up its contacts thereby opening both main operating circuits.

The ground lamp lights in case the positive wire is grounded when switch GS is thrown to the right, while a ground on the common wire would cause lamp to light up when switch is closed to the left.

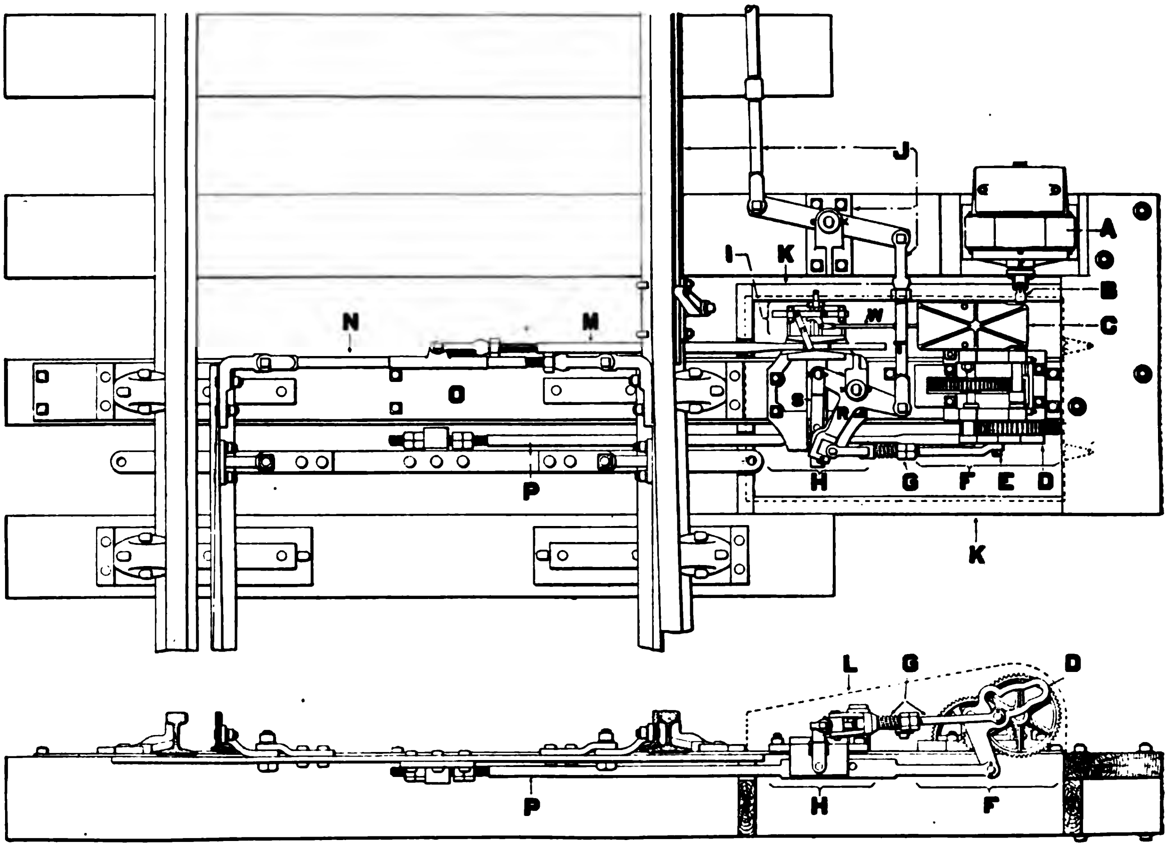
The levers in the figures from 1 to 4 inclusive are shown with circuits suitable for a distant signal, a two-arm home signal, a switch movement and a dwarf signal respectively.

The switch movement is controlled by means of two wires in addition to the main common wire, and the indication current, which is generated by the switch motor itself, is transmitted through the same wires and an indication common. In one position of the lever, one of these wires is the control and the other is the indication wire, while in the other position these conditions are reversed, that is, the wire which was originally the control becomes the indication, and the indication becomes the control wire. Each of these wires is connected to two contact springs at the circuit controller; in the normal position of the lever one of these wires is connected to the positive terminal of the battery through the coils of the safety magnet S and switch bus bar, and the other wire is connected to the indication common through the coils of the indication magnet I and the indication bus bar; when the lever is reversed these connections are reversed also.

A pole changer switch P is placed at the switch, being operated automatically by the lock plunger in the last part of its movement after it has passed through the lock rod and locked the switch. Connection is made between the movable part of the pole changer and the lock plunger, motion being imparted through the medium of pole changer movement I, Fig. 1671. The arrangement of this mechanism is such that two pins mounted upon the lock rod M cause the pole changer to throw in one direction when the switch has reached its normal position, and in the other when switch has reached its reversed position, thus accomplishing three objects: First, to cut the current off from the motor; second, to reverse the armature connections, and third, to complete the indication circuit.

The pole changer P (Fig. 1665) consists essentially of two movable contacts and eight fixed contact springs. Each armature terminal of the motor is connected to two of the fixed contact springs, one field terminal to two others, and each control wire to one of the remaining contact springs. The other field terminal is connected to the main common. The connections are such that in one position of the pole-changer terminal A of the armature is connected to one of the control wires and terminal B′ to the field coils, while in the other position terminal B′ is connected to the other control wire, and terminal A to the field coils.

In the diagram (Fig. 1665) the functions are shown in the normal position. In this position the normal operating wire is connected to battery, but no current flows because it is disconnected at the pole changing switch. If the lever 3 is reversed, the reverse control wire is placed in connection with battery, causing current to flow from battery through the safety and control devices on the power and operating boards, to switch operating bus bar, fuse, safety magnet S^3, indication selector coil, circuit controller contacts 2 and 3, the reverse control wire, pole-changer, contacts 4 and 5 switch motor armature A^3, pole changer contacts 6 and 7, the field coils F, to main common return and back to battery. The motor operates the switch mechanism and when the switch has completed its movement, the lock plunger changes the pole changer from contacts 4-5 to contacts 8-9 and from contacts 6-7 to contacts 10-11, disconnecting the reverse control wire from the armature, connecting the terminal A instead of B′ with the field coils and connecting the terminal B′ with the reverse indication wire.



Figs. 1671-1672. Electric Switch and Lock Movement.

Names of Parts, Electric Switch and Lock Movement; Figs. 1671-1672.

A	*Motor*	**H**	*Lock Movement*	**N**	*Front Rod*
B	*Connecting Shaft*	**I**	*Pole Changer Movement*	**O**	*Tie Plate*
C	*Pole Changer*	**J**	*Detector Bar Operating Mechanism*	**P**	*Throw Rod*
D	*Cam Crank*			**R**	*Lock Crank*
E	*Driving Pin*	**K**	*Long Ties*	**S**	*Lock Link*
F	*Gears and Frame*	**L**	*Outline of Cover*	**T**	*Detector Bar Driving Link*
G	*Driving Rod*	**M**	*Lock Rod*	**W**	*Pole Changer Rod*

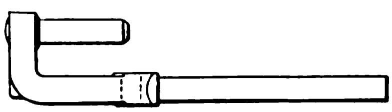


Fig. 1673. Lock Plunger; Locks Both Lock and Throw Rods.

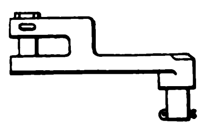


Fig. 1674. Link S, Figs. 1671-1672.

Fig. 1675. Throw Rod, with Tappet for Lock Plunger. See H, Fig. 1671.

An electric motor when driven by a current tends to develop an electromotive force in opposition to the driving electromotive force and after the current is cut off the armature continues to rotate from acquired momentum and continues to develop this electromotive force. The new connections made by the pole changer as above described are such that the current thus developed leaves the armature at terminal A, passes through the field coils in the same direction as the driving current flowed, thus maintaining their magnetization through the main common to the indication common, through the indication common to the magnetic cutout H on the operating switchboard and the indication bus bar, indication coils I^3, indication selector contacts 13 and 12, contacts on controller, reverse indication wire (which is the normal operating wire for the other position), pole changer contacts 8 and 9 to the terminal B′ of the armature, thereby energizing indication magnet I^3 and effecting release locking as explained in the operation of the lever, Figs. 1649-1650.

Indication selector RC-NC (see also Fig. 1648) is arranged in such a manner that energy flowing through operating wires attracts the armature, and closes the contacts for reverse indication when the reverse operating wire is energized, and for the normal indication when corresponding operating wire is energized. From the above it will be seen that in order to cause a false indication current to flow through the indication magnet I^3 three conditions must be fulfilled: First, the operating current must be cut off; second, the indication wire must be put in connection with the motor armature, and third, the connection between the armature and fields must be reversed. The first of these might be caused by a broken wire; the second by crossed wires, and the third would require two breaks and two crosses at certain points. A combination of all three together require prearranged conditions and movements which are considered impossible of accidental occurrence. While a switch is under operation a cross between the normal and reverse wires would send current from the battery back through the indication

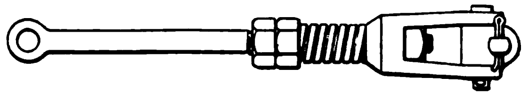
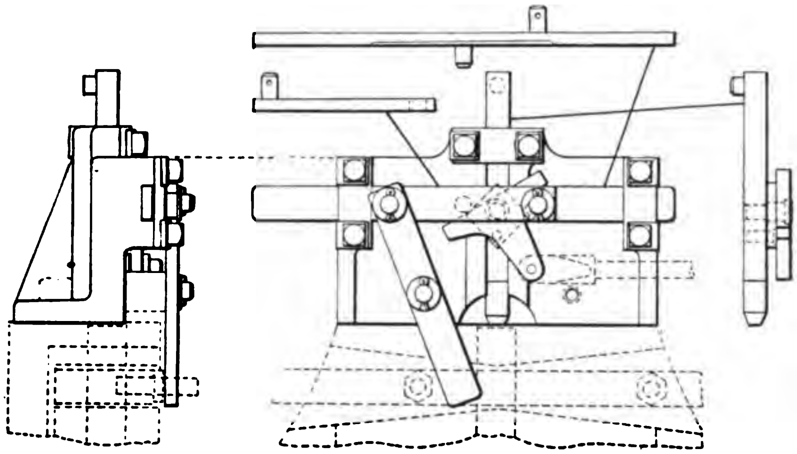


Fig. 1676. Driving Rod G, Figs. 1671-1672.



Figs. 1677-1681. Pole Changer Movement I, Figs, 1671-1672.

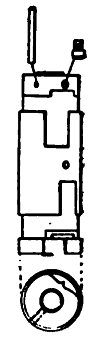
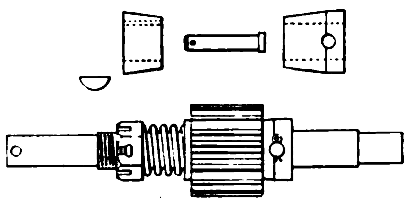
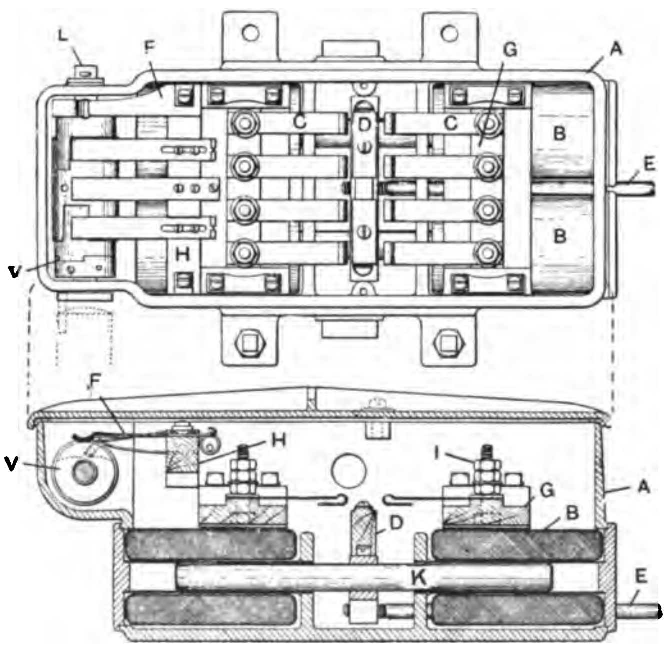


Fig. 1682. Commutator V, Figs. 1688-1689.

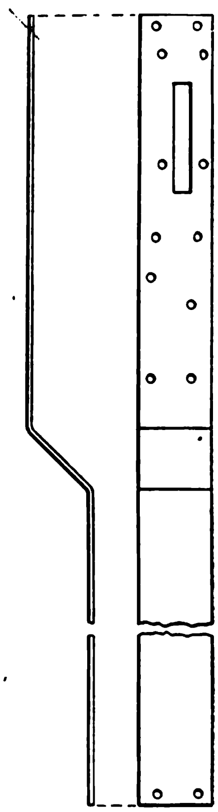


Figs. 1683-1687. Friction Clutch.

Letters Refer to List of Names of Parts Below.



Figs. 1688-1689. Pole Changer C, Figs. 1671-1672.



Figs. 1690-1691. Tie Plate, with Slot for Gear Wheel O, Figs. 1671-1672.

Names of Parts, Pole Changer; Figs. 1688-1689.

A *Case*
B *Solenoids*
C *Contact Springs*
D *Contact Block*
E *Operating Rod*
F *Snap Spring*
G *Contact Block*
H *Contact Block*
I *Binding Posts*
K *Armatures*
L *Shaft*
V *Commutator*

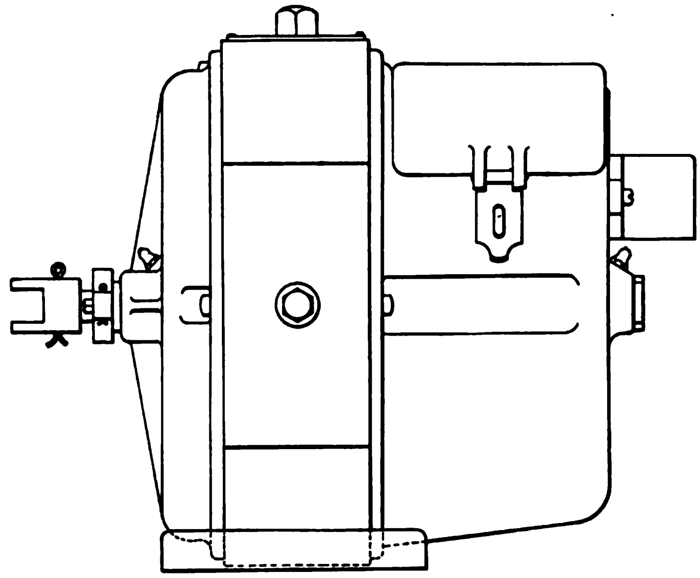
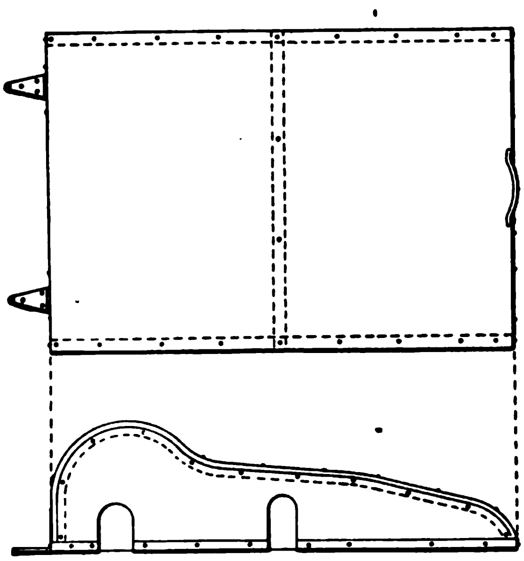
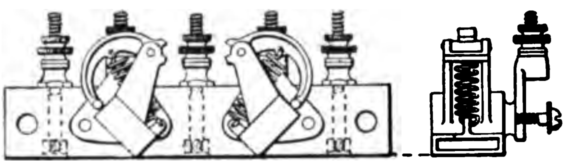


Fig. 1692. Motor A, Figs. 1671-1672.



Figs. 1693-1694. Switch and Lock Movement Cover L, Figs. 1671-1672.



Figs. 1695-1696. Motor Brush Holder.

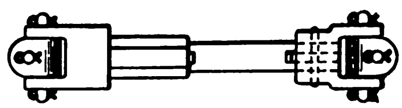


Fig. 1697. Connecting Shaft B, Figs. 1671-1672.

magnet, but a false indication is prevented by safety magnet S^2 which prevents the indication coils I^2 from attracting the armature as explained.

Placing the lever 3 in normal position again connects the normal control wire with battery through safety magnet S^2, coil NC of indication selector, contacts 16 and 17, normal control wire to pole changer contacts 8 and 9, and armature terminal B', the current passing through and leaving at A, that is in the reverse direction to that sent through it in reversing the switch, the current flowing through the fields in the same direction as before. The armature rotation is consequently reversed and the switch rail is moved back to its normal position. At the end of the movement the pole changer P is shifted back to the position shown in the diagram and the indication current is generated as before. It however leaves by the terminal B' and returns to the terminal A through the normal indicating wire.

The pole changer P besides being operated automatically by the lock plunger is, during all the intervening time, under control of the lever by means of the magnets M and M'. The magnet M has one terminal connected to the normal control wire and the other to the main common wire. The magnet M' has one terminal connected to the reverse control wire and the other to the main common wire. When the normal control wire is connected to battery current flows through the magnets M and when the reverse control wire is connected to battery, current flows through the magnet M'. These currents are strong enough to shift the pole changer whenever it is free from the lock plunger, which is during the whole switch movement and during all the lock plunger movement except the first and last three-quarters of an inch. If the switch lever 3 is reversed to reverse the switch, the reverse circuit is energized as explained above, current flowing through the switch motor in the proper direction and through the magnets M'. The current thus holding pole changer in position to maintain the current in the motor. If for any reason it is desired to put the switch back normal before it has completed its reverse movement, as for instance, where the points are blocked by snow, or other obstruction, it is only necessary to place the lever back to normal indication point; this will energize the normal circuit including magnets M, shift the pole changer into position to send the current through the motor, the pole changer shifting back to the position shown at the end of the movement, and the indication current being developed as before. No current is sent through the indication magnets when the magnets M shift the pole changer for the reason that the controller connected to the lever is in the wrong position with reference to the pole changer, and should the magnet fail to work none is developed for the reason that the connections between the armature and field coils are not correctly made to generate energy, it being necessary to reverse them before this can occur. Circuit breaker CB shown in the diagram is operated automatically by the switch movement, and cuts off current from the magnets M-M when switch is normal, and from M'-M' when switch is reversed, this taking place only when the switch is home and securely locked in position.

When it is desired that two switches be operated together, for instance both ends at a crossover, a special short lever is used for one and a standard lever for the other. These two levers are placed next to each other in the machine and connected by a bar so that they move together.

The two-arm home signal No. 2 is shown selected through a switch box at No. 3 switch. The signal circuits are shown for a model 3 enclosed signal (Figs. 1700-1711), operated at 110 volts, having a dynamic indication. The operation is as follows:

When the lever 2 is reversed the signal mechanism is connected to battery through the signal bus bar, contacts 1 and 2, indication magnet I^2, the control wire, the circuit breaker G, the armature A^2, and field coils F^2, selector coils S or S^1 depending upon the position of switch 3, through a contact at the switch box to main common. This current, if the switch is normal, energizes the selector coil controlling the upper arm and the motor, causing the armature to rotate and thus to clear the signal. When the signal arm is clear circuit breaker G opens, causing current to flow through high resistance brake magnet B^2 so that the current is reduced to the very small quantity required to hold the signal mechanism at clear. Energizing the brake magnet sets a friction brake on a disk connected to the armature shaft and holds the signal clear as long as the lever 2 is in the reverse position. The current which operates the signal motor was shown to have passed through indication coils I^2. This is done for the purpose of releasing the lever 2 from the latch L^2 and permitting it to make the full stroke to reverse position. This is not in a strict sense an indication of the clear position of the signal, but no indication is considered necessary for that position as no release locking is effected by the final movement excepting that between distant and home signals, and this is provided for in the circuit breaker controlled by the home signal.

When the lever 2 is placed normal the circuit through the brake magnet B^2 is broken at controllers 1 and 2, and the control wire is put into connection with the indication common through the indication magnet. This releases the brake B^2, opens the circuit and causes the signal arm to assume normal position. The crosshead, meanwhile, in returning to normal position drives the armature in the opposite direction to that taken while clearing the signal, thus developing an electromotive force. When the crosshead has reached the normal position it closes the circuit at con-

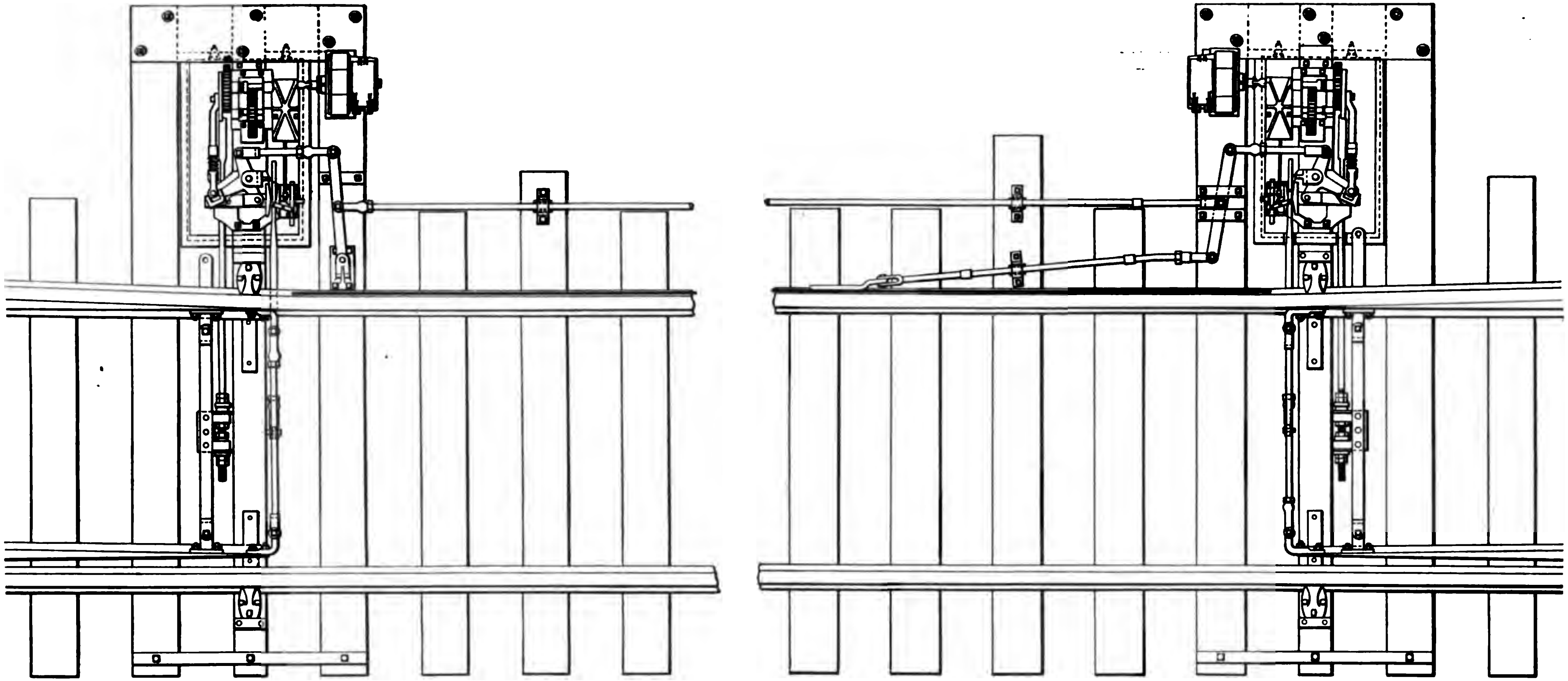


Fig. 1698. Method of Operating One Detector Bar from Two Switch Movements. General Railway Signal Company.

tacts G, completing the following circuit: From the motor armature through the field and selector coil S', closed contacts at switch box to the main common and indication common, through the indication common to cutout coils H, the indication bus bar, contacts 3 and 4, the indication magnet coils and through contact G to armature. This current energizes the indication magnet I² and effects the release of the lever as described in the case of switch 3, permitting the final part of its movement to be made. It also checks the rotation of the armature and thus serves the purpose of a cushion to the falling counterweight. The lower arm is operated in exactly the same manner, the contacts at the switch causing selector coils S to be energized instead of S', thus clearing the lower arm instead of the upper. The indication current being developed in the same manner as explained for the upper arm.

The distant signal is operated, and indication current generated in the same manner as described for the home signal, the operation being controlled by lever 1 and circuit controller on home signal. The control wiring runs directly to this distant signal, the only difference being that there are no selector coils and that the current is provided with a path through a wire connection through the controller on home signal to main common thence to indication common.

Lever 4 controls a dwarf signal which is provided with a solenoid having two windings, one of low resistance called the working coil and designated as W and W' in the diagram, and one of high resistance called the retaining coil and designated as R and R'. It has two circuit controllers operated by the signal arm, one of which controls the indication circuit, and is closed only where the signal arm is normal; the other controls the working circuit and is open only when the signal is reversed. The dwarf circuit controller connected to the operating lever consists of eight fixed contact springs and the movable contact block. Two of these contact springs at the end of the controller are long, so that they connect with the movable strip during the preliminary and final movement of the lever. The other two at each end are short, so that they make contact with the other movable strip only when the lever is stopped by the latch L⁴. As it is impracticable to obtain a dynamic current from the solenoid for indication purposes, as is done in case of the switch and signal motor, current for the indication from the dwarf signal is obtained from the battery.

One terminal of the indication magnet is connected permanently to the positive pole of the battery and the connections to the dwarf circuit controller are such that when the lever is at the normal indication point, the control wire is connected to the indication bus bar and the free terminal of the indication magnet is

connected to the indication wire. At the reverse indication point the control wire is connected to the positive pole of battery, and the free terminal of the indication magnet is connected to the negative side of the battery through the indication common and main common wires. In the full normal and reverse position the control wire will retain the connection that it had at the corresponding indication points, but the indication magnet is cut off to prevent unnecessary waste of current or heating of the coils.

When the lever 4 is reversed the control wire is connected to the battery and the current flows through the working coil W, the circuit breaker G^4 to the main common. This pulls the signal arm to clear position which opens circuit breaker G^4 and cuts in the retaining coil which is in shunt with it. The current in the retaining coil holds the signal in the clear position. The indication magnet is connected to the battery at the indication point, for the purpose of releasing the lever to make its final movement to reverse position. As with the high signal this is not actually an indication of the clear position of the signal, but in this case also no indication is considered necessary for the reason that no locking is to be released by the final movement of the lever to the reverse position.

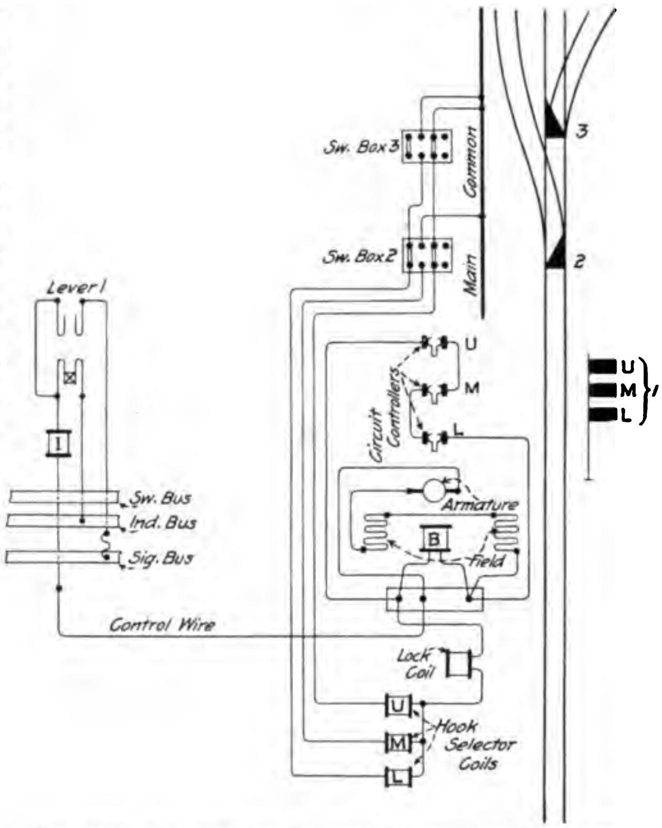


Fig. 1699. Circuits for Selected Three-Arm Signal and Safety Lock.

Fig. 1700. Model 3, Signal Mechanism in Case.

This arrangement is employed merely for the purpose of obtaining uniformity in the construction of the switch and signal levers.

When the lever 4 is pushed back normal the circuit through the retaining coil is broken and the signal arm returns to the stop position. When it reaches this position, the circuit breaker D connects the indication wire with the common at the signal, and as the movement of the lever to normal has put the free terminal of the indication magnet I^4 in connection with the indication wire a current flows through the indication magnet and effects the release of the lever from latch L^4 permitting it to be placed in full normal position thus effecting release locking.

To guard against injurious effects of crosses between any of the wires, precautions both in circuit and mechanical arrangement are taken. One arrangement is as follows: H on the operating switchboard is a polarized cutout normally held closed in the position shown in the diagram. Should a cross occur with any of the operating wires, the polarized relay would operate, thus opening controlling circuit breaker MS, and preventing further operation of any of the functions until the removal of the trouble. An indication of the trouble would be given at the operating board, however, as the red lamp mounted thereon would light up showing that the polarized cutout had operated.

It will be seen that all wires which are in operative connection at the function are also connected at the interlocking machine to the negative pole of the battery through the indication bus bar, the cutout H, the indication common and the main common so that current reaching any of these wires, on account of being crossed with a live wire will flow through the coil H, in a direction to operate the polarized relay thus cutting off the current which might otherwise effect a false movement. The resistance of this return path is less than that through the motor to the main common, so that the greater part of the current, due to a cross, must flow back through the coil H. The windings of the coil H are so proportioned that any current due to a cross strong enough to move a motor will attract the armature of the polarized cutout to the other pole, throw the automatic circuit breaker open, and cut off all current from the crossed wires before any false operation of the motor can take place. Figs. 1772-1773 illustrate, diagrammatically, the action of this apparatus, the wires shown heavy with arrows indicating the flow of current.

The indication common is led out to a distance from the tower where it joins the main common. This is done to avoid the effects of drop in potential in the main common due to the working of a number of switches and signals. If the indication common were connected directly at the battery this drop in potential would tend to send a current back through the indication wire of some other function not under operation and would in some cases open the

Fig. 1701. One-Arm, Model 3 Signal Mechanism.

Fig. 1702. Two-Arm, Model 3 Signal Mechanism.

cutout unnecessarily, thus causing annoyance. By joining the indication common to the main common at a distance from the battery, this drop in potential is avoided. In large plants, where it would be undesirable to permit one cross to put all functions out of service, the functions are divided into groups, each group having a separate circuit breaker and common wire (Fig. 1779), in which case a cross in one group will not affect the operation of functions in other groups.

The mechanical locking is effected by locking dogs which are actuated by the tappets, and connected to locking bars in the same manner as the vertical locking in mechanical machines (Figs. 661-881).

The switch machine proper of electric switch and lock movements as connected to a single switch is shown in Figs. 1671-1672. It consists of a connecting shaft B, gear frame F, lock movement H with its driving rod G, pole changer movement I, pole changer C and cover L. (See also Figs. 1673-1697.) The connecting shaft B is flexible in all directions and renders the maintenance of a careful alignment between motor and gear frame unnecessary. The function of the gear frame F is, first, to reduce

Fig. 1703. Front View Two-Arm, Model 3, Slotted Signal.

Fig. 1704. Rear View Two-Arm, Model 3, Slotted Signal.

the speed of the motor and correspondingly increase its power to an amount suitable for the movement of the switch and detector bar; and second, to disengage the motor after the switch machine has entirely completed its stroke. The disengagement of the motor is effected by means of a friction clutch mounted upon a shaft connected to the armature shaft, Figs. 1683-1687. After the switch mechanism has completed its movement either to the reverse or normal position, this clutch allows the motor to run on momentum and generate the indication current necessary to effect release locking at the lever, and also eliminates the injurious strain which would otherwise fall upon the motor, the adjustment of the clutch being such as to enable the armature of the motor to rotate without undue strain. The movement of the switch, detector bar and lock plunger is effected by the pin E (Fig. 1671), on the main gear which connects direct with the lock movement by the rod G and to the switch by engagement with the cam crank D. It is through the medium of the lock movement H that the lock plunger, detector bar and pole changer are operated. Motion is transmitted to the crank R by the rod G, to the lock plunger by link S and to the detector bar by the link T. Since both detector bar and plunger are driven by the same crank, if a train occupying the track prevents the movement of the detector bar, the plunger cannot be withdrawn. Motion is imparted to the pole changer C through the medium of the pole changer movement I, after the lock plunger, in returning, has passed entirely through the hole in the lock rod M. By the pole changer movement mechanism, Figs. 1677-1681, acting in combination with two pins on the lock rod M, the pole changer C is caused to throw in one direction when the switch has reached its normal position, and in the other when the switch has reached reversed position. A revolving circuit breaker V, Figs. 1688-1689, is arranged to cut current off from the magnets of the pole changer whenever the switch is in its full normal or reverse position (see Fig. 1665). The gear frame and lock frame together with the stock rails are shown securely bolted and braced to a rigid tie plate O (see Figs.

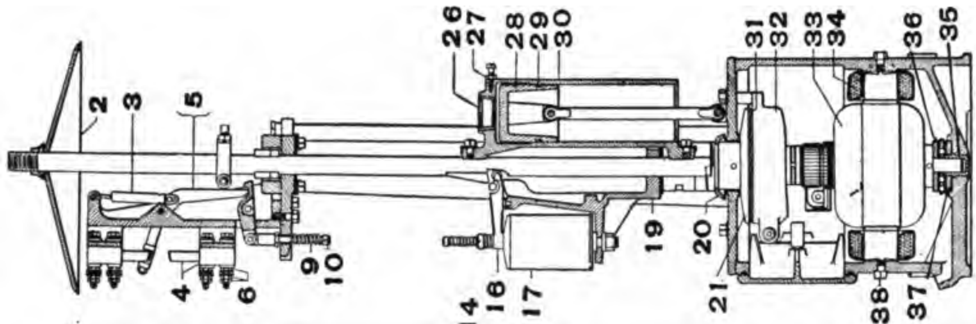


Fig. 1709. Side View Two-Arm, Model 3, Signal Mechanism, Slotted.

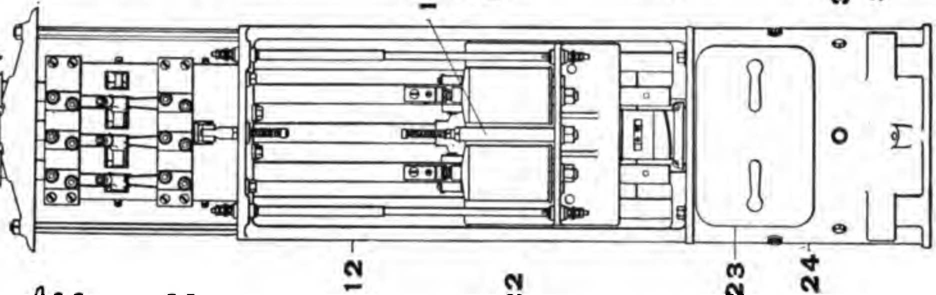


Fig. 1708. Front View Two-Arm, Model 3, Signal Mechanism.

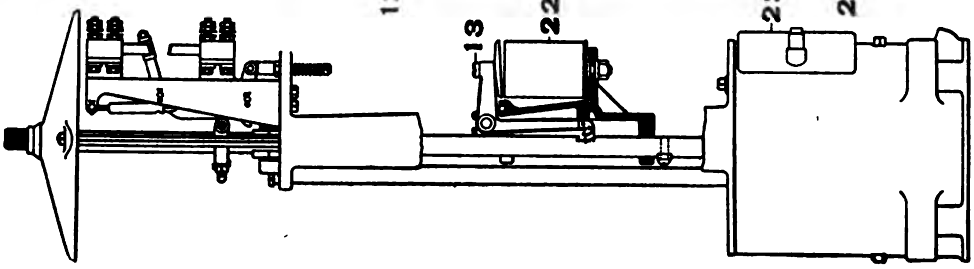


Fig. 1707. Side View Two-Arm, Model 3, Signal Mechanism.

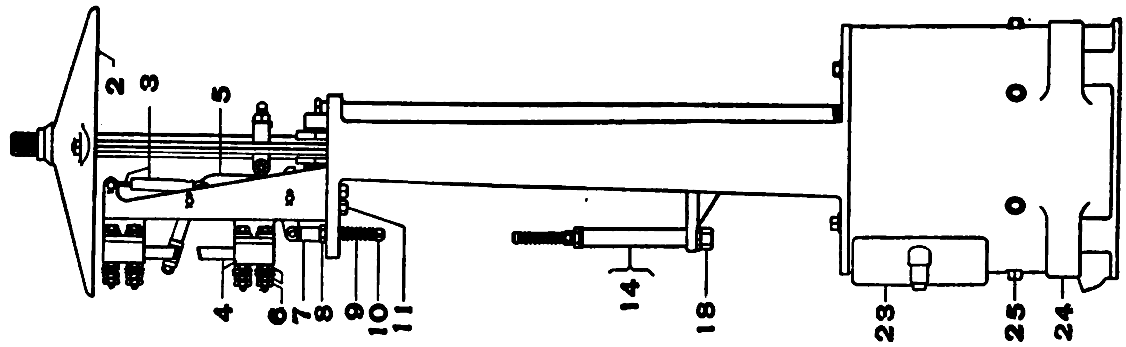


Fig. 1706. Side View One-Arm, Model 3, Signal Mechanism.

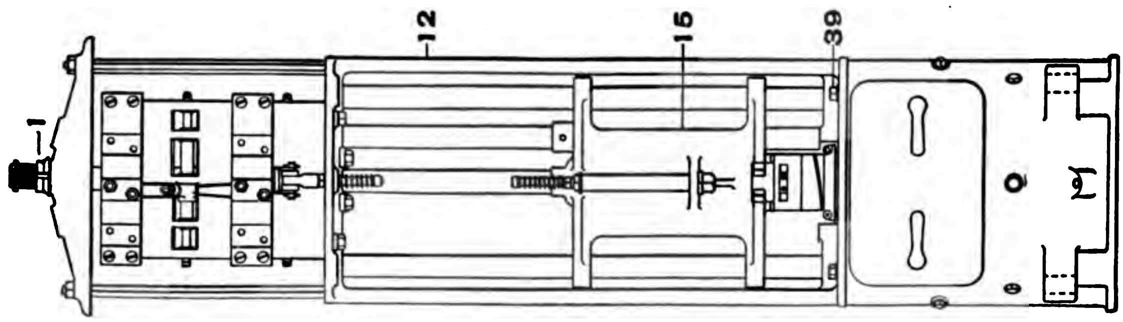


Fig. 1705. Front View One-Arm, Model 3, Signal Mechanism.

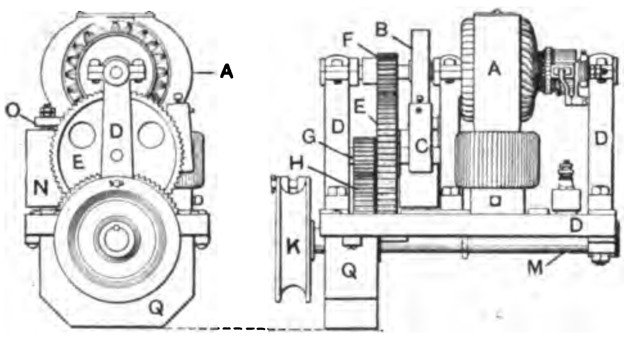
Names of Parts, Model 3 Signal Mechanism; Figs. 1705-1709.

1 *Small Shield, Protecting Mechanism Against Water*
2 *Large Shield, Protecting Mechanism Against Water*
3 *Encased Circuit Breaker Spring*
4 *Stationary Contact*
5 *Contact Arm*
6 *Brass Nut*
7 *Eye for Operating Circuit Breaker*
8 *Nut for 10*
9 *Spring*
10 *Plunger for Operating Circuit Breaker*
11 *Cap Screw*
12 *Main Frame*
13 *Special Screw for Armature*
14 *Post for Operating Circuit Breaker*
15 *Crosshead for One-Arm Signal*
16 *Latch for Slotted Signal*
17 *Slot Magnet*
18 *Nut*
19 *Crosshead for Two-Arm Signal*
20 *Oil Shield*
21 *Brake Disc*
22 *Selector Magnet*
23 *Door*
24 *Motor Case*
25 *Cap Screw*
26 *Socket Plug*
27 *Jam Nut*
28 *Plunger for Dashpot*
29 *Plunger Ring*
30 *Dash Pot*
31 *Bronze Disc*
32 *Brake Coil*
33 *Armature*
34 *Field Coil*
35 *Bushing for Thrust Bearing*
36 *Upper Plate for Thrust Bearing*
37 *Lower Plate for Thrust Bearing*
38 *Cap Screw*
39 *Cap Screw*

Figs. 1710-1711. Two-Arm, Model 3 Signal.

Figs. 1712-1713. Two-Arm Outside Connected Signal.

Figs. 1714-1715. One-Arm Outside Connected Signal.



Figs. 1716-1717. Motor Mechanism, Outside Connected Signal.

Names of Parts, Motor Mechanism for Outside Connected Signal; Figs. 1716-1717.

A	*Field*	**H**	*Main Gear*
B	*Brake Wheel*	**K**	*Chain Sheave*
C	*Brake Counterweight*	**M**	*Main Shaft*
D	*Frame*	**N**	*Brake Magnet*
E	*Intermediate Gear*	**O**	*Brake Armature*
F	*Motor Pinion*	**Q**	*Gear Case*
G	*Intermediate Pinion*		

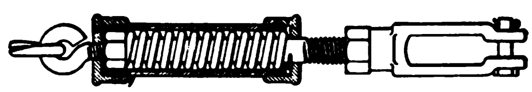
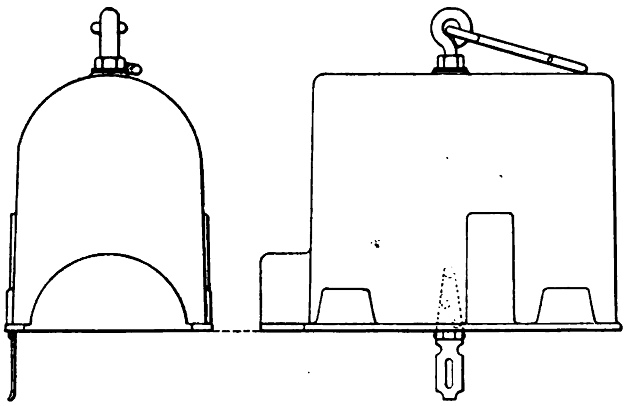


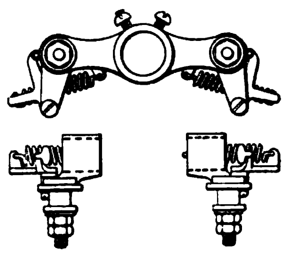
Fig. 1718. Case and Spring Connection, D Figs. 1712-1713.

1690-1691), which maintains all parts in their proper relation to each other. The lock, front and throw rods are shown at M, N and P respectively.

The operation of a switch mechanically is as follows: Current having been delivered to the motor as already explained, it is set in motion and operating through a train of gears, carries the main gear with pin E, Fig. 1671, through a complete revolution. During about one-third of the revolution the lock bolt is withdrawn and the detector bar raised simultaneously. When the bar has reached its highest position, the pin E, coming in contact with the outer end of the cam crank D, throws the switch during the next one-third of the revolution. During the final one-third the lock plunger is returned to its place and the detector bar lowered. After the lock plunger passes through the lock rod the pole changer is thrown and at the same time the motor is disengaged as explained above. It will be seen that with this switch movement the stroke of the detector bar is from one end to the center and return, the bar never reaching the extreme reverse position as it does when connected to a mechanical switch and lock movement.



Figs. 1719-1720. Mechanism Cover, Outside Connected Signal.



Figs. 1721-1723. Details of Brush Holders, Outside Connected Signal.

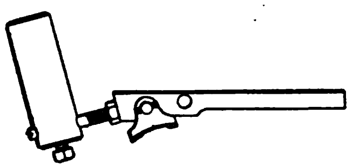


Fig. 1724. Details of Brake, Outside Connected Signal.

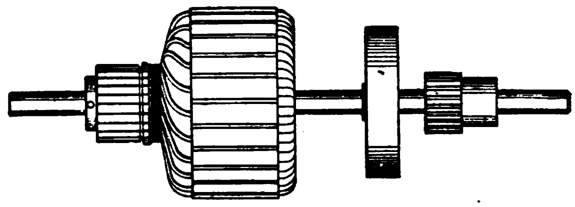


Fig. 1725. Motor Armature, Commutator, Brake Wheel and Pinion, Mounted on Shaft, Outside Connected Signal.

Fig. 1698 illustrates an arrangement for throwing one detector bar from two switch movements. The device consists of a floating lever at B, centrally connected to a pivoted lever at A. The upper extremity of each lever is connected to the lock crank of its respective switch movement. The lower end of the lever at A is pivoted and that of the lever at B is connected to the detector bar. Now, if the upper end of the lever at B be moved to the left the lever will move about its center as an axis and the bar will be moved. In this case the center of the lever is held stationary by the rod and the lever at A. If the lever at A be moved to the right, it will move the connecting rod, which will transmit motion to the lever at B. This lever will move to the right about its upper end as an axis and the bar will be thrown. These levers are so proportioned that in either of the above cases the bar would be moved through half its full stroke, that is, to the center and back. If, now, both switches should be moved at once the bar would move through its full stroke and back, as the upper end of lever at B would be moved to the left at the same time that its center was moved to the right.

A Model 3 signal mechanism for a one-arm enclosed signal is shown in Figs. 1701 and 1705-1706. The mechanism consists of the signal machine, arranged for 60, 75 or 90 degrees as required, connecting rod, crosshead, frame and the necessary circuit controllers. The motor is mounted in a thrust bearing and is rigidly maintained in position by action of the upper and lower bearings. A worm directly connected to the armature shaft, actuates the crosshead through a ball-bearing nut when the armature revolves. The operation of the signal was explained in connection with Fig.

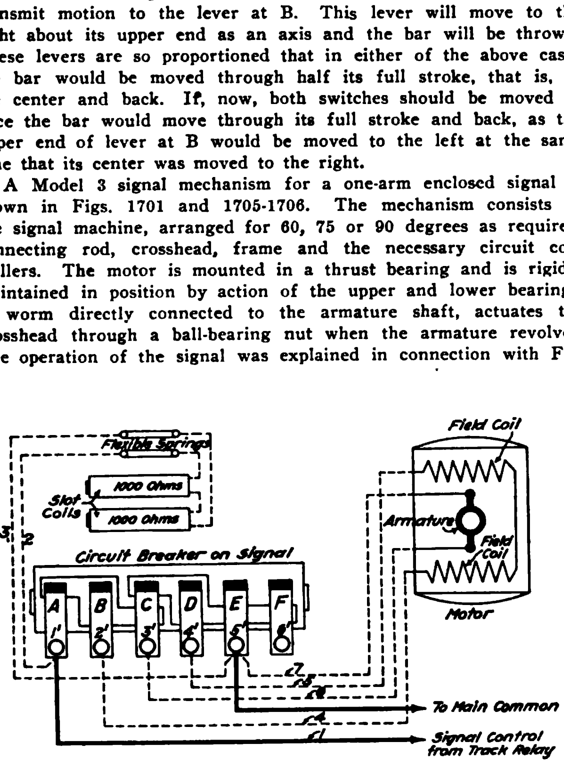


Fig. 1726. Wiring Diagram for Model 5 Signal When Used in Interlocking. (For Views of Signal Mechanism, See Figs. 429-434.)

1665. Figs. 1705-1706 show the general arrangement and method of operating the brake contact, which is shown in the upper portion, the contact shown as closed provides the low resistance path to the motor, and when open cuts in the brake circuit. When the signal is clear the lower contact closes, thus providing a path for any outside circuit such as a distant signal, indicator or repeater.

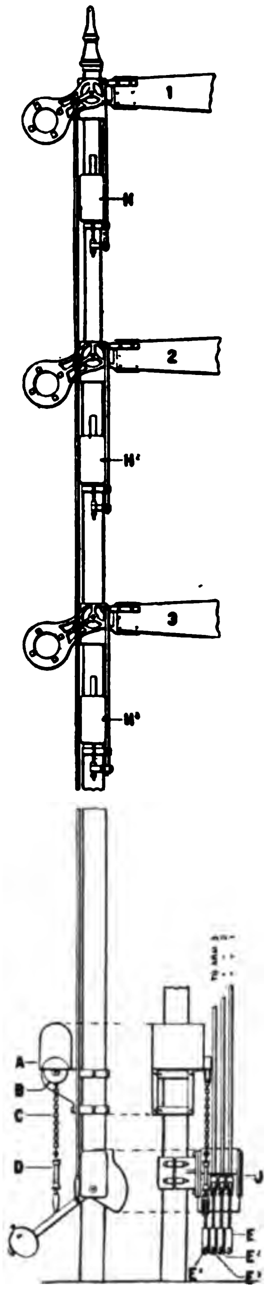
The arrangement employed for a two-arm slotted or selected signal is shown in Figs. 1700, 1702-1704 and 1708-1709, also the arrangement of the motor and other working parts. The selector magnets 22 (Fig. 1707), when energized, cause the signal crosshead to engage with the signal rod through action of the dog operated by the armature, and the signal clears when the crosshead is raised. The contacts cut in the high resistance brake when signal arm is clear. This signal is fitted with dynamic indication which is also controlled by the contact shown.

The outside connected signal used in connection with all electric interlocking is shown in Figs. 1712-1715.

The signal movement is more fully shown in Figs. 1716-1725. The machine consists of an electric motor, a train of gears and a magnetic brake. The motor armature with its brake disk and pinion is shown in Fig. 1725.

The operation of the signal is as follows: Current is delivered to the motor by the reversal of the lever on the interlocking machine. The armature is set in motion, and acting through the train of gears revolves the chain sheave B, Fig. 1713 (also see K, Fig. 1717), winds up chain C which, acting through the flexible connection D (also see Fig. 1718) lifts the counterweight lever and clears the signal in the usual manner. When the arm has reached the proceed position, the circuit breaker operates as already explained and sets the brake, which stops the motor. When it is desired to restore the signal to the stop position the lever is returned to the normal indication point, thus cutting off current from the brake magnets and motor. A circuit through the motor and indication magnets is then complete except at the signal circuit breaker. The motor is now free, the counterweight falls and the armature rotates in the opposite direction to that which cleared the signal; at the same time, the signal arm assumes the stop position. Just as the arm reaches the stop position, the circuit breaker completes the indication circuit, and the motor now acting as a generator sends in the indication and effects the release locking.

Figs. 1712-1713 show a standard two-arm high signal. Aside from the pole and its fittings the signal includes one signal movement A and two circuit breakers H^1 and H^2 (see also Figs. 1732-1749). The signal movement A is the same as used for the single arm signal except that the chain wheel is provided with sprockets for gripping the chain C which passes over it. When the motor armature revolves in one direction it clears the upper arm and when in the other direction the lower arm. For this purpose the fields are arranged with two windings, and the reversal of the armature rotation is effected through the switch selector operated by the switch points. When the lever is reversed, current flows



Figs. 1727-1728. Three-Arm Outside Connected Signal, with Selector.

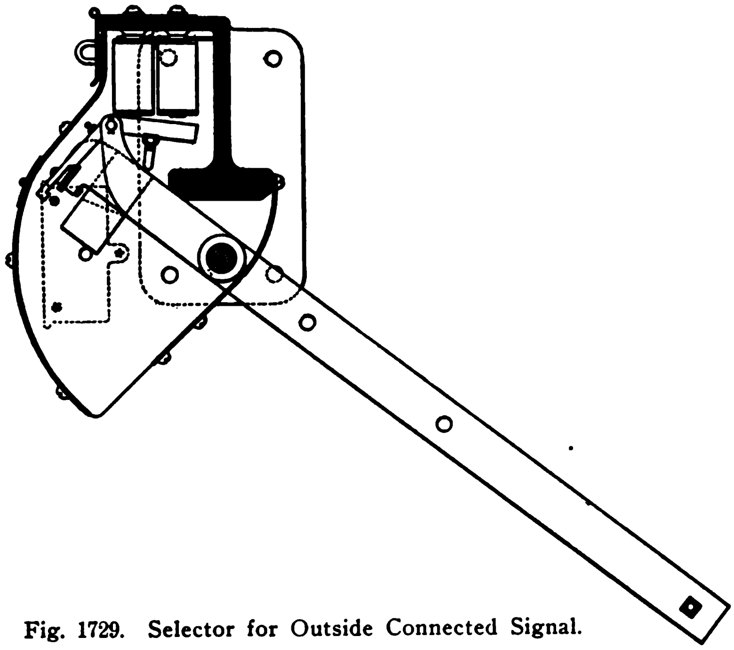
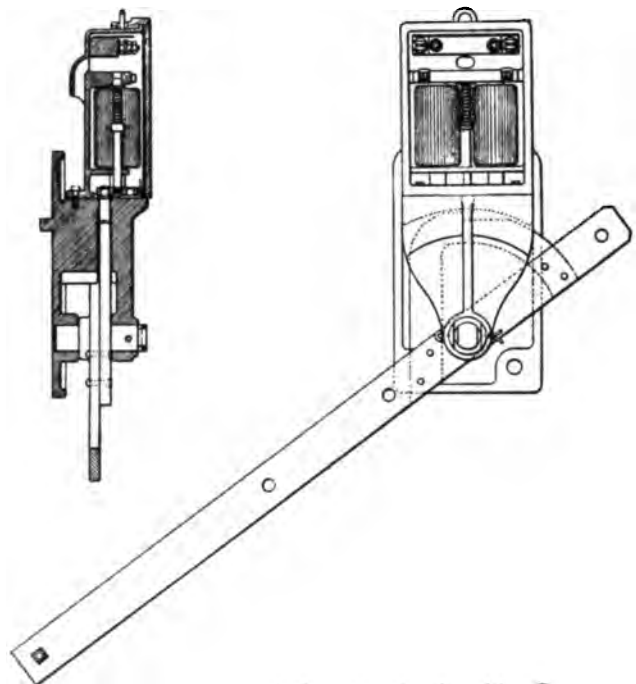


Fig. 1729. Selector for Outside Connected Signal.



Figs. 1730-1731. Safety Lock, Outside Connected Signal.

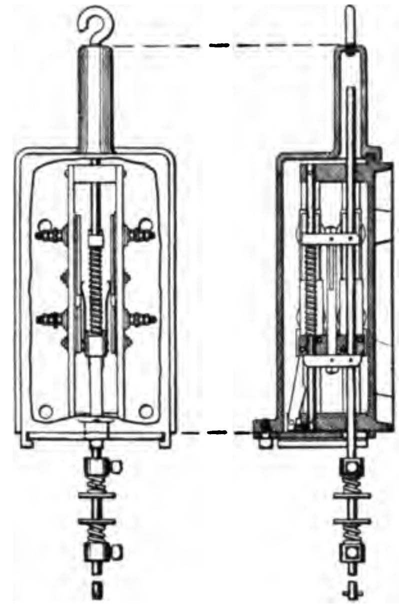
through the circuit as previously explained (Fig. 1665). This current, if the switch box is normal, will flow through one field coil and cause the armature to rotate in the proper direction to clear the upper arm. If the switch is reversed when the signal lever is reversed, the current passes through the second field coil rotating the armature in the proper direction to clear the lower arm.

When the lower arm is placed normal the indication is developed in the same manner as described for a single arm signal.

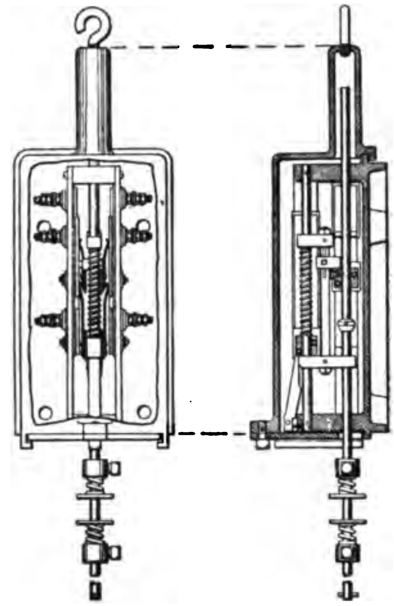
The Model 5 signal shown in Figs. 429 and 434 is adapted to use in connection with interlockings as a power operated block or distant signal. Fig. 1726 shows the local signal circuit employed for the purpose, the arrangement is such that rapid operation of the signal arm is effected, an efficient motor brake being provided to control the final movement of the mechanism in such a manner as to eliminate undue strain upon the moving parts. With reference to the diagram, energy enters the local signal circuit through wire 1, binding post 1', wire 2, and flexible springs to slot coils, thence through wire 3, binding post 5', to common, thus energizing the slot coils which are of sufficient resistance to properly distribute the current through the motor circuit, which is accomplished as follows: From binding post 1', energy flows through closed contacts A and B, post 2', wire 4, motor fields in series, wire 5, contacts D and C, wire 6 to the armature, thence through wire 7 to common. The electrical mechanism now being energized, the signal arm assumes the clear position; contacts from A to B and from C to D break, while contacts from B to C and from D to E make, thus energy is disconnected from the motor, which continues to revolve, due to the velocity attained while energized, thus setting up an electromotive force through a local circuit as follows: From the motor armature through wire 6, contacts CB, wire 4, motor field coils, wire 5, contacts D E, wire 7, back to the armature. This reverses the current in the armature and applies an effective motor brake.

Figs. 1730-1731 show a safety lock applied to outside connected signals to prevent false clearing of the signal. It consists of a magnet whose armature carries a dog resting normally against a projection on a quadrant attached to the counterweight lever. The control circuit passes through this magnet and raises the armature allowing the signal to be cleared.

A selector for outside connected signals is illustrated in Figs. 1727-1729. One magnet with armature is furnished for each arm. Each armature carries a pawl which engages with a lug on the motor counterweight arm when the magnet is energized. The armature is pivoted on the counterweight arm for its signal and moves with it. The arrangement of circuits used in connection with this form of selected signals, with the safety lock (Figs. 1730-1731) also in use, is shown in Fig. 1699.



Figs. 1732-1733. Circuit Breaker. Outside Connected Signal.



Figs. 1734-1735. Double Circuit Breaker. Outside Connected Signal.

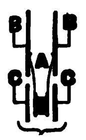


Fig. 1743.

Fig. 1744.

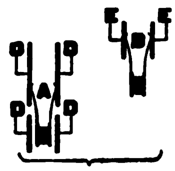


Fig. 1745.

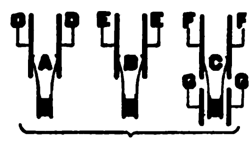


Fig. 1746.

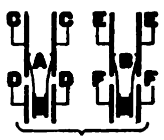


Fig. 1747.

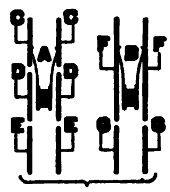


Fig. 1748.

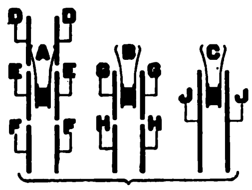


Fig. 1749.

Figs. 1743-1749. Circuit Breaker Diagrams.

Fig. 1743 *Shows the Contacts for* 2 *Position Circuit Breaker*
Circuit **B B** *Remains Closed Until Signal is Clear*
Circuit **C C** *Remains Closed Until Signal is at Stop*
Contact **A** ***Snaps From Stop to Clear, But Not From Clear to Stop***

Fig. 1744 *Shows the Contacts for* 2 *Position Inverted Circuit Breaker*
Circuit **C C** *Remains Closed Until Signal is Clear*
Circuit **B B** *Remains Closed Until Signal is at Stop*
Contact **A** *Snaps in Both Directions*

Fig. 1745 *Shows the Contacts for* 2 *Position Circuit Breaker*
Circuit **C C** *Remains Closed Until Signal is Clear*
Circuit **D D** *Remains Closed Until Signal is at Stop*
Circuit **E E** *Opens as soon as Signal Starts to Clear*
Contact **A** ***Snaps From Clear to Stop, But Not From Stop to Clear***
Contact **B** *Does Not Snap*

Fig. 1746 *Shows the Contacts for* 2 *Position Circuit Breaker*
Circuits **D D**, **E E**, *and* **F F** *Remain Closed Until Signal is Clear*
Circuit **G G** *Remains Closed Until Signal is at Stop*
Contacts **A**, **B** *and* **C** *Move Together and Snap From Clear to Stop, But Not From Stop to Clear*

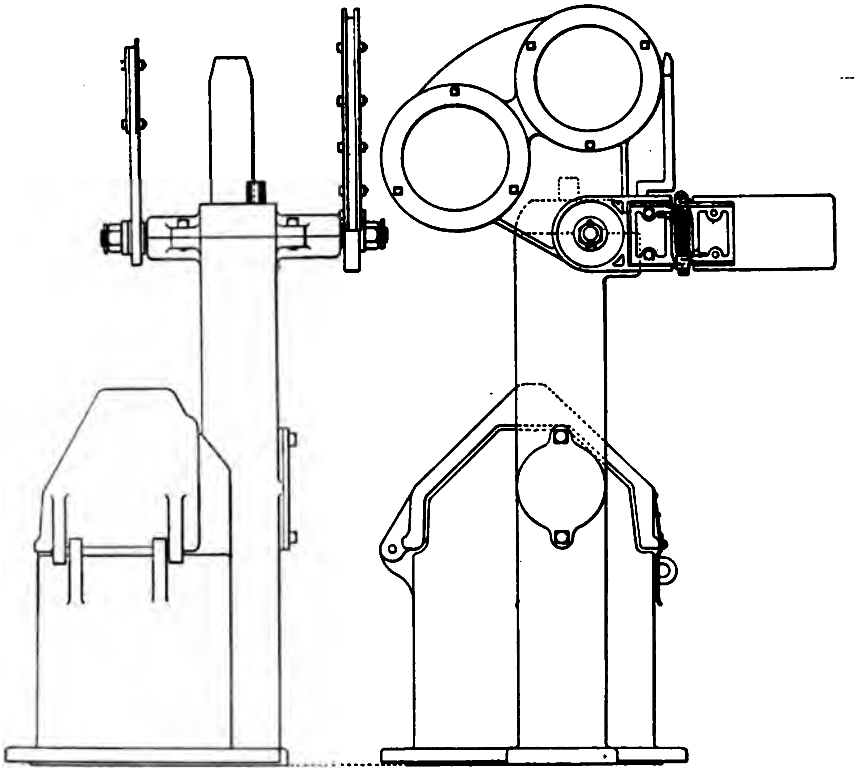
Fig. 1747 *Shows the Contacts for* 2 *Position Circuit Breaker*
Circuits **C C** *and* **E E** *Remain Closed Until Signal is Clear*
Circuits **D D** *and* **F F** *Remain Closed Until Signal is at Stop*
Contacts **A** *and* **B** *Move Together and Snap* ***From Clear to Stop, But Not From Stop to Clear***

Fig. 1748 *Shows the Contacts for* 3 *Position Circuit Breaker*
Circuit **C C** *Remains Closed Until Signal Has Reached the Caution Position*
Circuit **D D** *Remains Closed Until Signal Has Reached the Clear Position*
Circuit **E E** *Remains Closed Until the Signal Has Returned to Caution*
Circuit **D D** *Remains Closed Until the Signal* ***Has Returned to Stop***
Circuit **F F** *Remains Closed Until Signal is Clear*
Circuit **G G** *Remains Closed Until Signal is at Caution*
Contacts **A** *and* **B** *Move Together and Snap* ***From Stop to Caution, From Caution to*** *Clear, From Clear to Caution, and Caution to Stop*

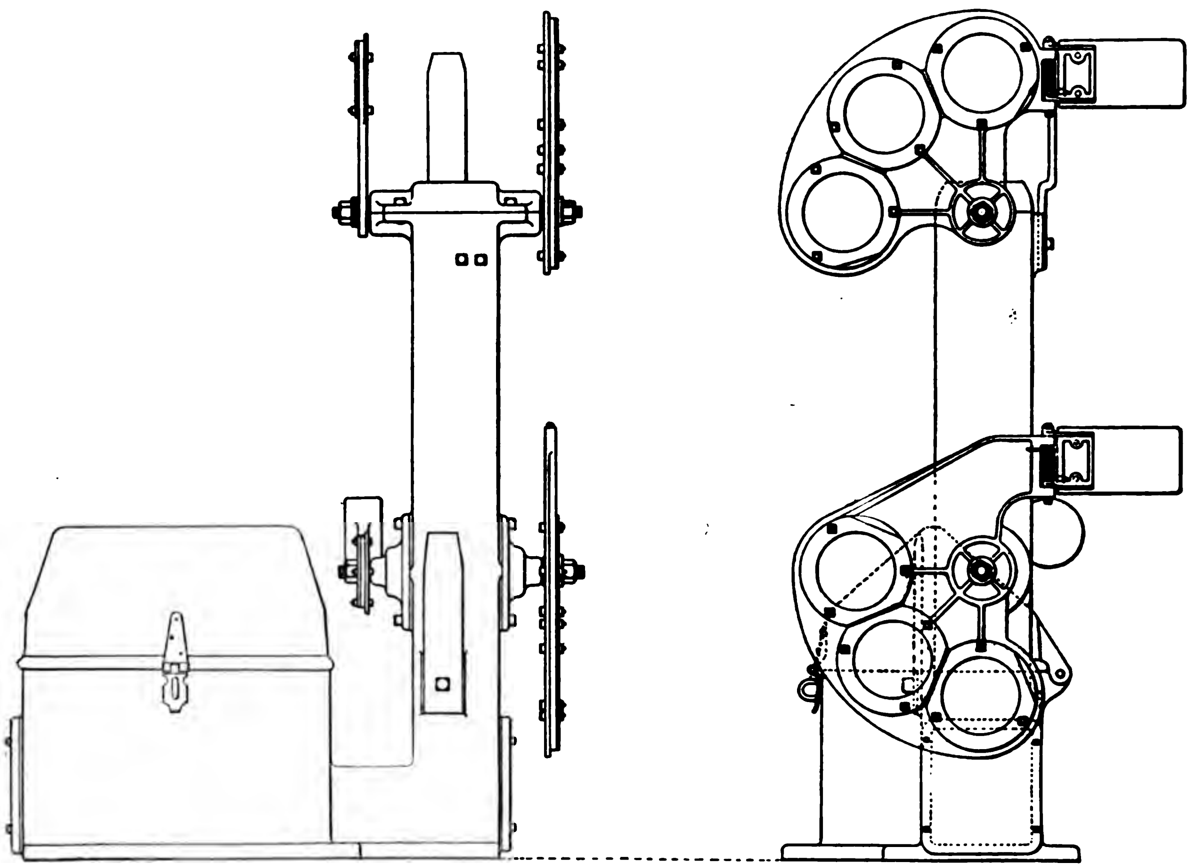
Fig. 1749 *Shows the Contacts for* 3 *Position Circuit Breaker*
Circuit **D D** *Remains Closed Until Signal Has Reached the Caution Position*
Circuits **E E** *and* **G G** *Remain Closed Until Signal Has Reached the Clear Position*
Circuit **J J** *Remains Closed From Caution to* ***Clear and From Clear to Caution***
Circuits **F F** *and* **H H** *Remain Closed Until Signal Has Returned to Caution*
Circuits **E E**, **G G** *and* **J J** *Remain Closed Until* ***Signal Has Returned to Stop***
Contacts **A**, **B** *and* **C** *Move Together and Snap* ***From Stop to Caution, From Caution to Clear, From Clear to Caution, and Caution to Stop***

Fig. 1750. Derail and Signals.

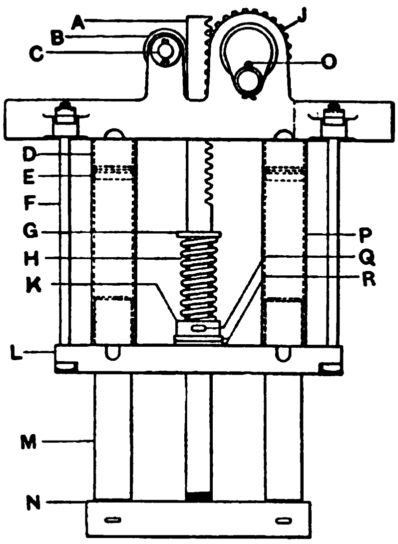
Fig. 1751. Switch Instrument or Selector. (For Details see Figs. 1765-1769.)



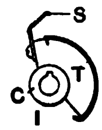
Figs. 1752-1753. Two-Position Electric Solenoid Dwarf Signal.

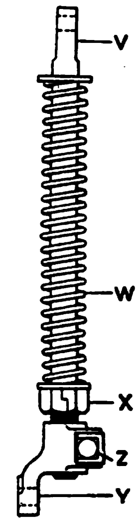


Figs. 1754-1755. Two-Arm, Three-Position Electric Solenoid Dwarf Signal.



Letters Refer to List of Names of Parts Below.

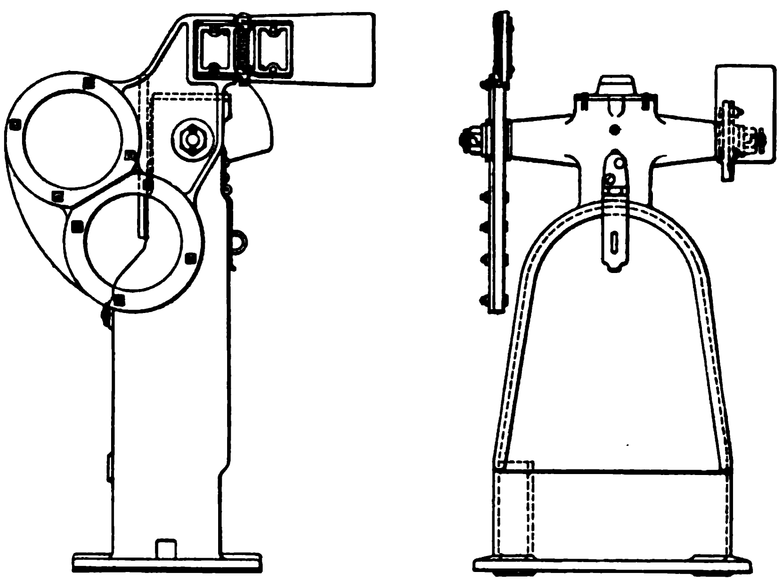




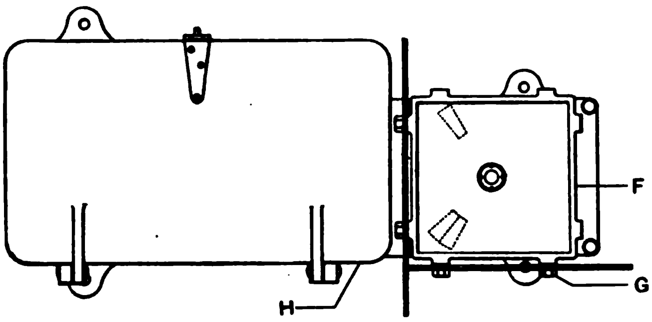
Figs. 1756-1758. Details of Solenoid Dwarf Signal, Figs. 1752-1755. O Is Normally off Center, Locking the Signal in the Stop Position.

Names of Parts of Model 2, Electric Dwarf Signal; Figs. 1756-1758.

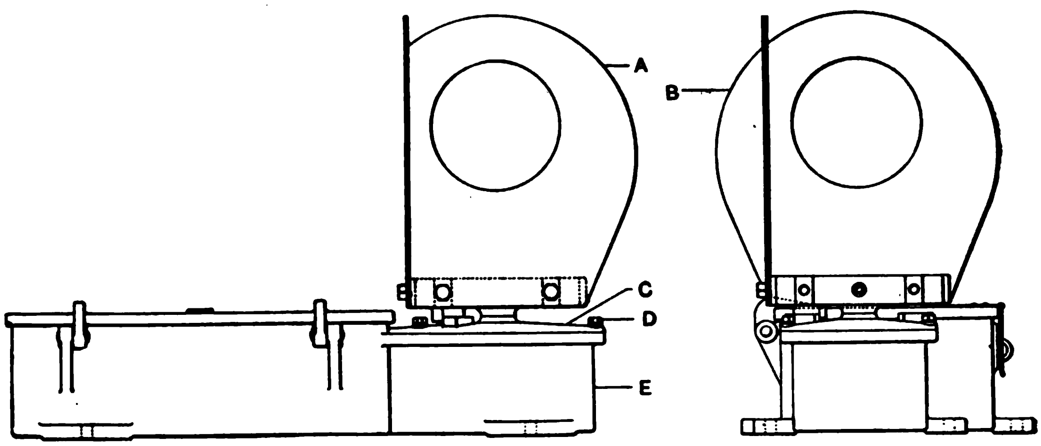
A	*Rack*	**J**	*Pinion*	**S**	*Contact*
B	*Roller*	**K**	*Collar*	**T**	*Insulating Segment*
C	*Shaft for* **B**	**L**	*Bottom Support for* **H**	**V**	*Operating Rod*
D	*Magnet Core, Brass*	**M**	*Armature*	**W**	*Spring*
E	*Cap For* **D**	**N**	*Yoke*	**X**	*Elastic Nut*
F	*Bolt*	**O**	*Crank*	**Y**	*Eye*
G	*Washer*	**P**	*Tube, Brass*	**Z**	*Clamp Screw*
H	*Restoring Spring*	**Q**	*Cotter*		
I	*Commutator, Indication*	**R**	*Washer*		



Figs. 1759-1760. Two Position Electric Solenoid Dwarf Signal.



Letters Refer to List of Names of Parts Below.



Figs. 1761-1763. Electric Solenoid Pot Signal.

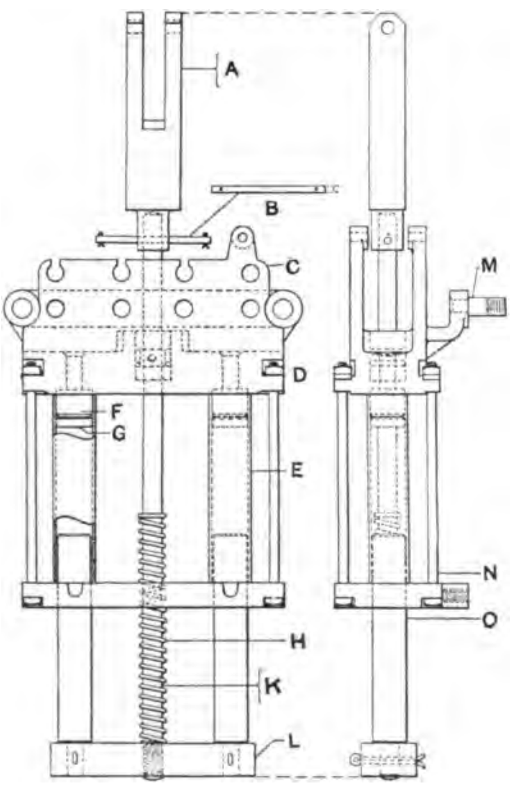


Fig. 1764. Details of Mechanism for Figs. 1759-1763.

Names of Parts of Electric Pot Signal; Figs. 1761-1763.

A *"Stop" Disc*
B *"Proceed" Disc*
C *Cover*
D *Cap Screw*
E *Case*
F *Lamp Stand*
G *Cap Screw*
H *Hinged Cover*

Names of Parts of Details, Model 3, Dwarf Signal; Fig. 1764.

A *Operating Jaw*
B *Indication Contact Arm*
C *Circuit Breaker Frame*
D *Lock Washer*
E *Spacing Tube*
F *Upper Core*
G *Copper Cap*
H *Restoring Spring*
K *Operating Rod*
L *Solenoid Yoke*
M *Stud for Holding* **C** *to Case*
N *Bolt*
O *Armature*

Letters Refer to List of Names of Parts Below.

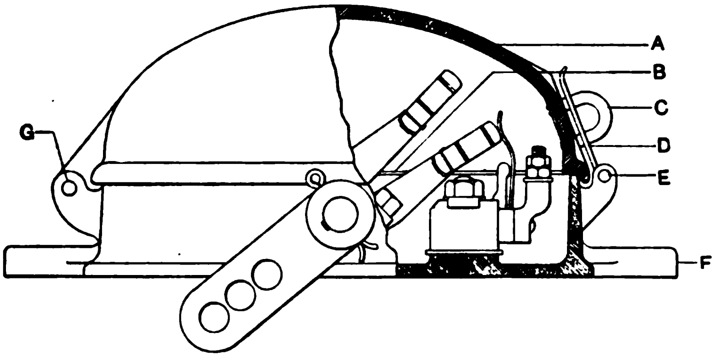
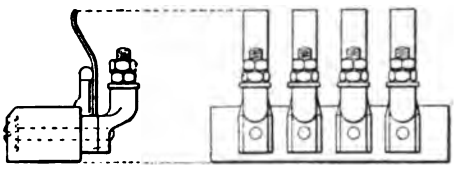


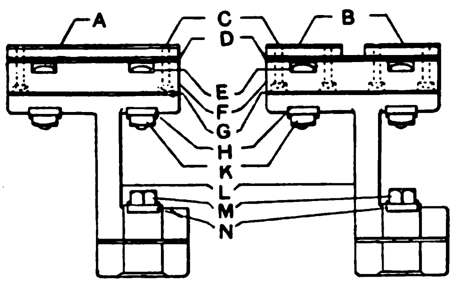
Fig. 1765. Switch Instrument or Selector. (See Fig. 1751).

Names of Parts of Switch Instrument; Fig. 1765.

A	*Cover*	**E**	*Hinge Pin for* **D**
B	*Felt Gasket*	**F**	*Base*
C	*Staple*	**G**	*Hinge Pin for* **A**
D	*Hasp*		



Figs. 1766-1767. Contacts and Support for Fig. 1765.



Figs. 1768-1769. Double and Single Contact Arms for Fig. 1765.

Names of Parts of Contact Arm for Switch Instrument; Figs. 1768-1769.

A	*Contact*	**G**	*Insulator, Mica*
B	*Contacts*	**H**	*Lock Washer*
C	*Screw*	**K**	*Nut*
D	*Insulator, Mica*	**L**	*Arm*
E	*Screw*	**M**	*Clamp Screw*
F	*Insulating Block*	**N**	*Lock Washer*

Fig. 1770. Operating Switchboard.

Fig. 1771. Operating Switchboard.

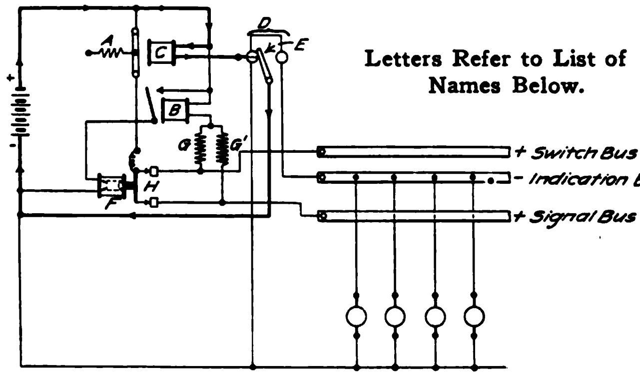


Fig. 1772. Normal.

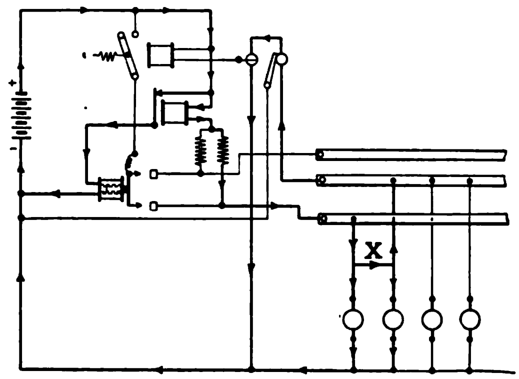


Fig. 1773. Effect of a Cross at X.

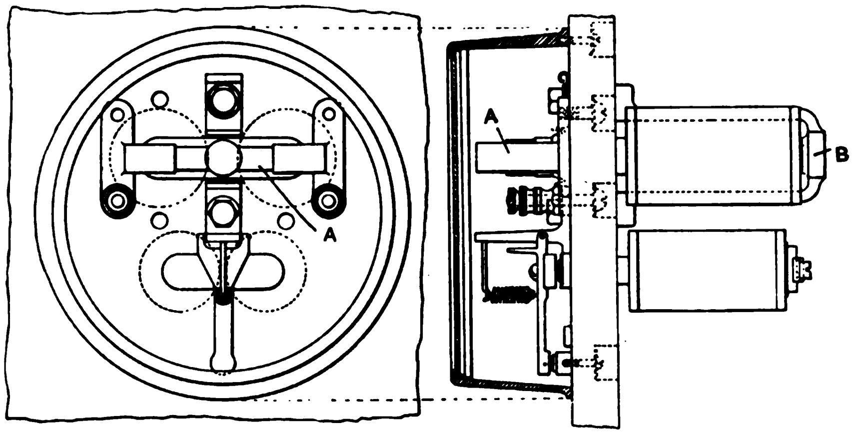
Figs. 1772-1773. Wiring Diagrams Showing Arrangement of Circuits and Apparatus on Operating Switchboard for Protection Against False Indications or False Movements of Functions Resulting from Crossed Wires.

Names of Parts of Fig. 1772.

- **A** *Circuit Breaker Spring and Lever*
- **B** *Actuating Relay*
- **C** *Circuit Breaker Magnet*
- **D** *Polarized Relay*
- **E** *Polarized Relay Armature*
- **F** *Circuit Breaker Relay Coil*
- **G** *Resistance Tubes (Ordinarily 60 Ohms Each)*
- **H** *Circuit Breaker Relay Contacts*

Fig. 1774. Electric Solenoid Bridge Lock.

NOTE.—This lock is operated by the same type of mechanism as dwarf signal Figs. 1752-1755.



Figs. 1775-1776. Circuit Breaker Relay for Operating Switchboard.

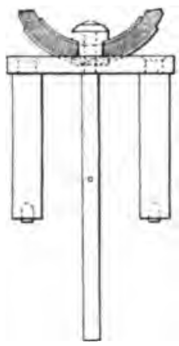


Fig. 1777. Brush Contact with Yoke and Core, (A, Figs. 1775-1776).

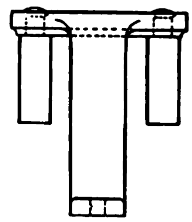


Fig. 1778. Back Yoke (B, Fig. 1776).

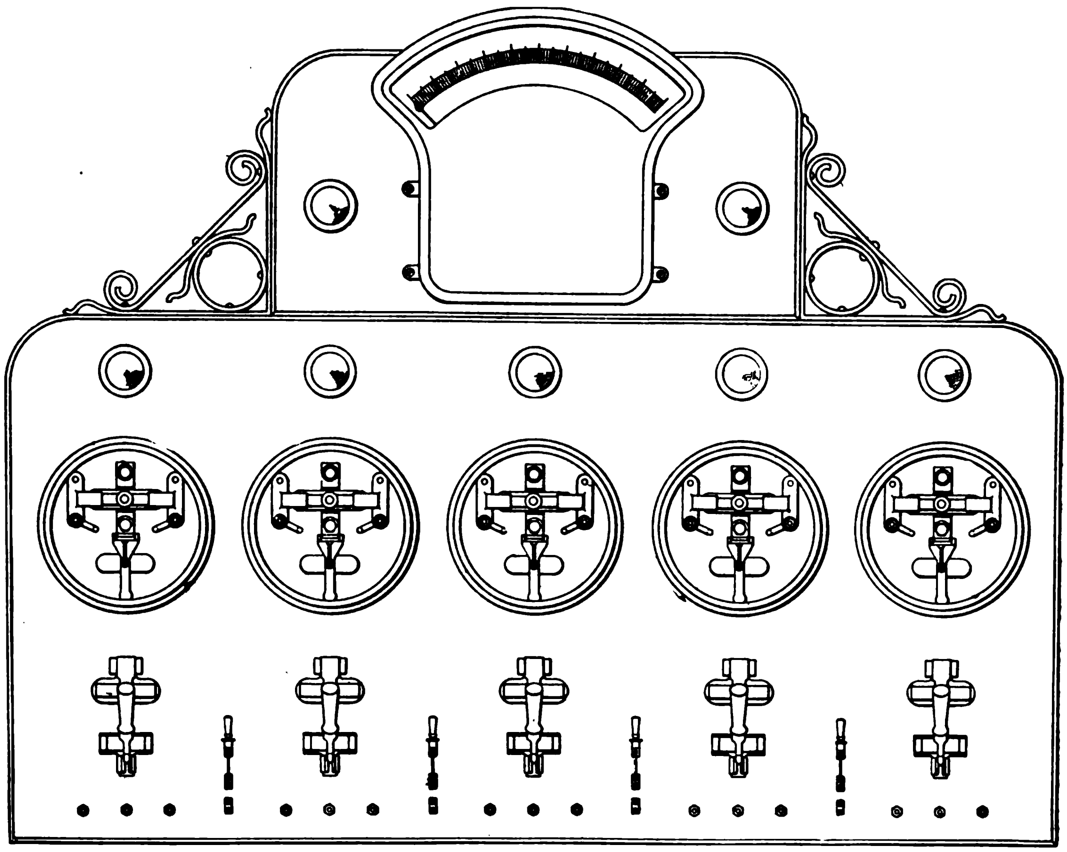


Fig. 1779. Special Operating Switchboard for Use Where the Functions Are Divided into Five Groups, Each Group Having a Separate Common Wire.

Fig. 1780. Electric Interlocking Machine. Electric Zone, New York Central & Hudson River.

Fig. 1781. Back View of Fig. 1780, Case Removed.

Fig. 1782. Part of Electric Interlocking Machine, Without Case, Showing Electro-Mechanical Screw Release. Electric Zone, New York Central & Hudson River.

The interlocking machine for the New York Central electric zone work, while conforming in principle and in general design to model No. 2 (Figs. 1641-1644), manufactured by the General Railway Signal Company, includes the following new features:

(a) An electro-mechanical screw release (Figs. 1782 and 2898).

(b) Electric lever locks (Figs. 2319 and B, Fig. 1781).

(c) A cabinet extending to the floor and arranged to be locked or sealed (Figs. 1780-1781).

(d) A terminal board equipped with polarized relays for the protection of each functional wire (A, Fig. 1781).

(e) Improved locking.

A front view of part of an interlocking machine with cabinet removed is shown in Fig. 1782. This shows the appearance of the improved locking which is similar in design to the back locking in the "Standard" Machine (Figs. 726-771) but of reduced size. It is arranged to take four bars in each groove of the locking plate, and is so designed as to require a smaller variety of dogs than the earlier type (Model No. 2) of this machine.

The model 4 switch machine shown in Figs. 1783-1788, inclusive, is a redesign of the Model 2 (Figs. 1671-1697). It is substantially constructed, rotating parts being bushed with bronze. All coils are taped, and subjected to the vacuum impregnation process. It can be used as either right or left hand without change, as it makes no difference to which side the lock and throw rods are connected. One or two adjustable lock rods can be used which permits the use of the machine for the operation of double slip or movable point frogs without additional facing point locks and connections. All parts are contained in a cast iron case which also forms a base plate for the mechanism, and is provided with a cover which affords protection against the weather. This case is bolted through tie plates to the head block and the next tie back. The armature has a free movement after completing the operation of the switch, which enables it to acquire momentum for generating the indication current.

The signal circuit controller (switch box) is provided with four normal and four reverse contacts; it is in the same case with other parts, and is under the joint control of locking movement and points in such a manner as to assure that the switch point is up to the stock rail, and also that it is locked in the proper position. Should the signal circuit controller become disconnected from the switch points, all of its contacts are opened. Duplex locking is provided by the use of locking plungers or dogs of different relative position which insures correspondence in position of the switch points and the machine. The removal of the brush holders and support permits the armature to be lifted out. The commutator and brushes are on top, making it easy to clean or inspect them.

By the use of a crank which is placed in the hole shown in the end of the armature A, Fig. 1783 (after one of the brushes has been raised from contact with the commutator in order to cut off current), the movement can be turned to any part of its stroke, for the purpose of adjusting any part or parts, without the assistance of the operator in the tower.

The motor is of the four pole type. The power is applied to the switch points through a train of gears having a friction clutch, the cones of which are provided with large wearing surfaces and are so tapered that they cannot wedge together. The bearing surfaces are ground true and separated by conical fibre rings which prevent cutting.

Referring to the illustrations, Fig. 1783 shows the movement with the main covers removed and with the individual covers open. Fig. 1784 shows movement with the main cam gear and locking bar and pole changer removed. Figs. 1786-1787 show the upper and lower sides of the main cam gear. Fig. 1785 shows the locking bar to which are attached locking plungers or dogs, cam slots, for the operation of switch box and setting the pole changer, and to which detector bar connections are attached. Fig. 1788 shows the movement as installed in the New York Central Electric Zone connected to a single switch, without a detector bar, electric detection (see definition) being used. Figs. 1666-1670, inclusive, show the wiring diagram of the switch as connected to the lever in the interlocking machine, the heavy lines and arrows in each diagram indicating the wires carrying current and the direction of flow during each position of the switch and the lever, from normal to reverse and return to normal. The cycle of operation is divided into five parts (each part representing about 90 degrees of travel on the main gear) as follows:

First fifth. Free.

Second fifth. Unlocking, during which detector bar is raised and switch box contacts opened.

Third fifth. Movement of the switch points.

Fourth fifth. Locking, during which detector bar is lowered, pole changer is set and switch box contacts closed (reversed).

Fifth fifth. Free movement, reversal of pole changer and stopping of motor. (The free movement is the major portion of this part of the stroke.)

The various movements as outlined above, are accomplished by the main gear, Figs. 1786-1787, the locking bar, Fig. 1785, the lock bolts N (Fig. 1785), and the throw rod M (Fig. 1783). The rollers O, O (Fig. 1785) on the locking bar engage with the cam U on the upper side of the main gear, the roller on N (Fig. 1784) engages with the cam T on the under side of the main gear and the roller V on the under side of main gear engages with the jaw of the throw rod M. Fig. 1783.

The cam U (Fig. 1787) causes an intermitten movement of the locking bar, the first part of which throws the circuit controller C, Fig. 1666, to a central position and closes the circuit of the pole changer coils corresponding to the movement being made (the circuit for the other set of coils being already closed) and raises the detector bar. The second portion of the locking bar stroke (after the period of rest) the circuit controller completes the movement of C, Fig. 1666, and sets the wings J, Fig. 1783, in position to engage with the cutout cams S S, Figs. 1786-1787, on the main gear, and lowers the detector bar. The movements of the switch box and the reversible pole changer being performed by means of the cam slots and cranks, not shown. An independent connection of the switch box to the points drops the movable contact piece immediately after the points begin to move, in which lowered position it will remain as long as the points are open.

After the movements above described are completed, the main gear continues to move until one of the cams S S engages with the wing J, which engagement reverses the pole changer, cutting off the operating current and closing the indication circuit, the current for which is generated b the motor running as a generator for the time being.

It will be noted that during the last fifth of the stroke, the only mechanical work performed by the machine is that of reversing the pole changers, consequently, the switch throwing and locking parts being at rest, the gears and armature acquire considerable inertia so that when the current is cut off and the

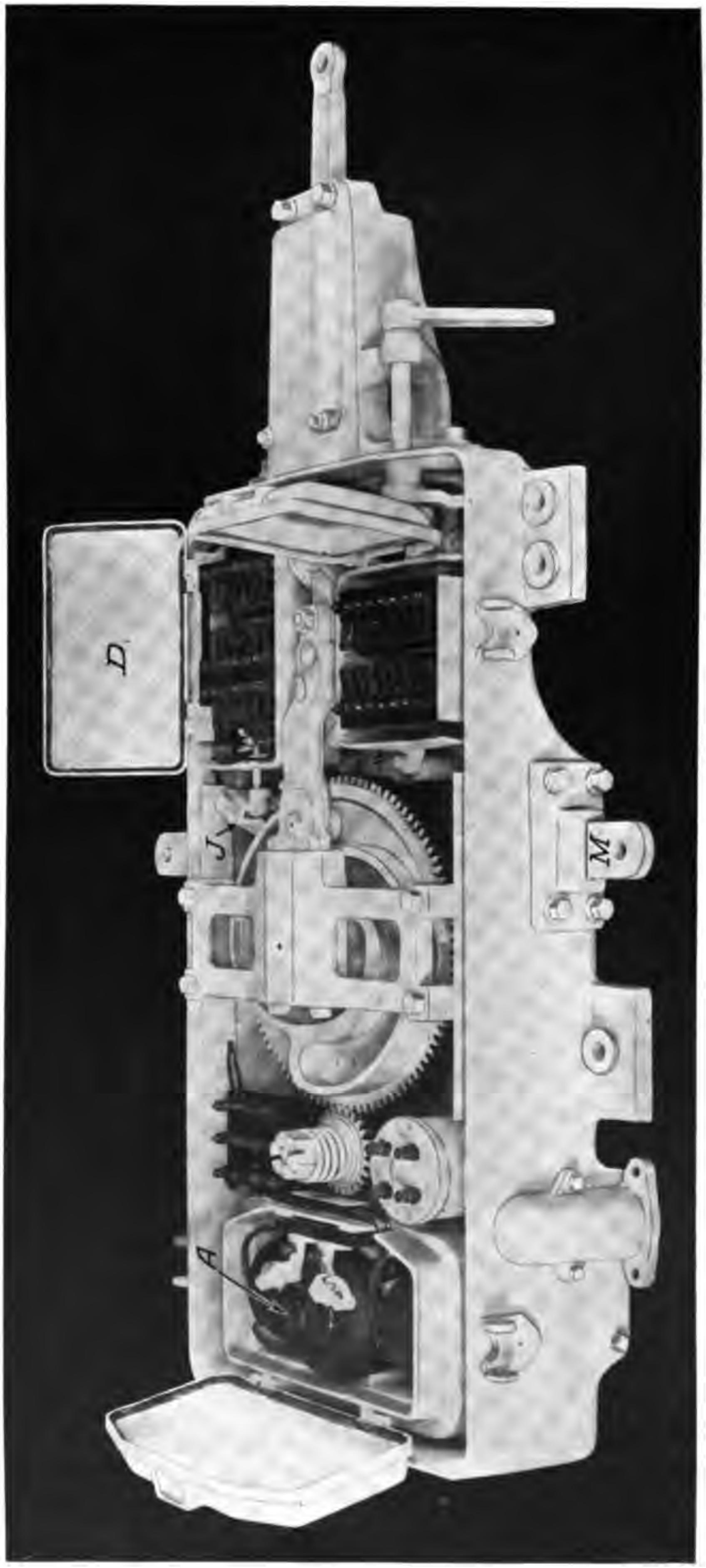


Fig. 1783. Model 4 Switch and Lock Movement.

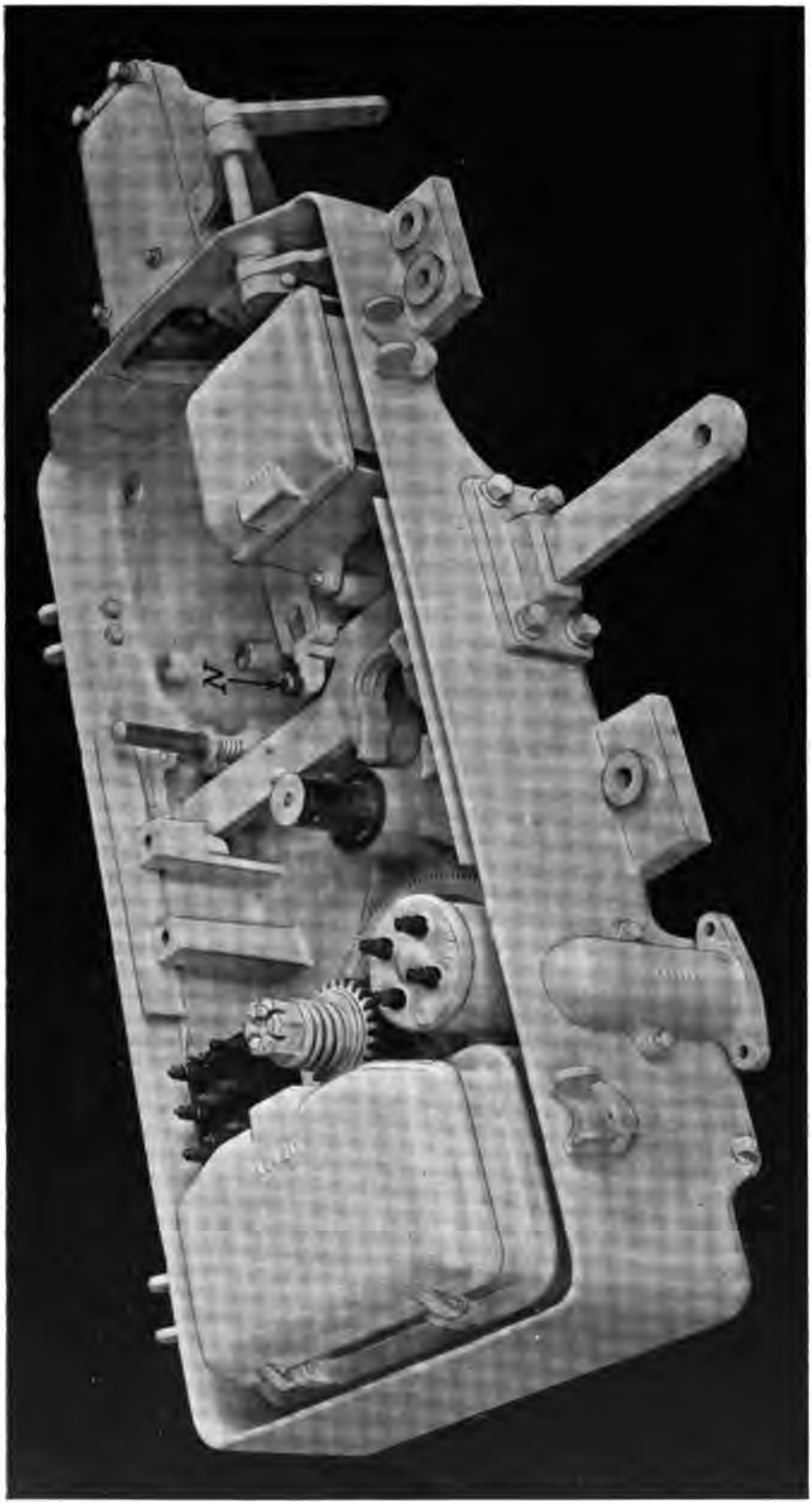


Fig. 1784. Model 4 Switch Movement with Main Gear, Locking Bar and Pole Changer Removed.

Fig. 1785. Locking Bar for Model 4 Switch Movement.

Fig. 1786. Top View, Main Cam Gear, Model 4 Switch and Lock Movement.

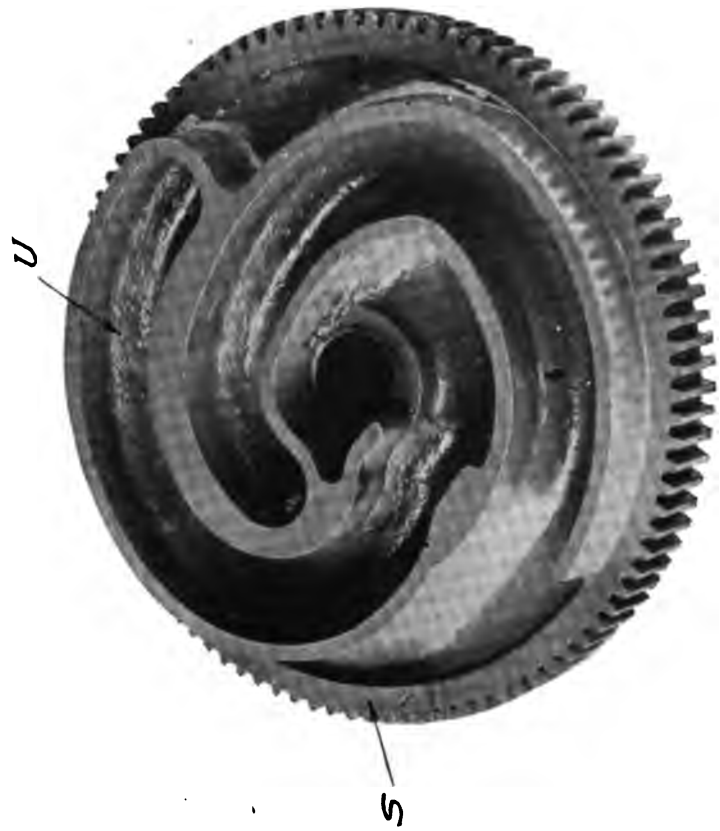


Fig. 1787. Bottom View, Main Cam Gear, Model 4 Switch and Lock Movement.

Fig. 1788. Model 4 Switch Movement, as Installed on Electric Zone; New York Central & Hudson River.

contacts transferred to the other position in the pole changer, the motor generates current, the direction and path of which is shown by Figs. 1668 and 1670. This momentary impulse energizes the magnets for the indicating device in the interlocking machine, tripping the releasing mechanism on the lever and allowing the operator to move it to the full normal or reverse position. The current thus generated also acts as a snub on the mechanism, bringing it to a stop without injurious shock.

Figs. 1792-1793 show the signal mechanism known as the Model No. 7. It is a modification of the Model No. 3 signal (Figs. 1700-1711), especially designed to handle a home and distant arm on the same post. This is accomplished by making the stroke of the mechanism slightly longer and dividing the travel of the cross-head into two parts, the first clearing the home and the second the distant signal. In this mechanism the slot or selector coils are stationary. Seven circuit breakers (front and back contact) are provided, which can be operated at varying periods of the stroke and will take care of any ordinary circuit requirements.

Where more than two arms are to be operated from one mechanism, it becomes necessary to use a selector head (Fig. 1794), one of these being required for every arm, more than one, that is to be operated from the same up and down rod. This is an electro-mechanical device for connecting the up and down rod to the shaft carrying the spectacle casting and blade. In other words, the mechanism is arranged to move two up and down rods successively, the first of which controls all of the home arms, the second of which controls all of the distant arms, and the particular arm of either group is electrically selected for mechanical connection to its operating rod.

The construction and operation of the selector head is as follows: The up and down rod is equipped with a double jaw which is pinned to the crank C. This crank works loosely about the semaphore shaft and carries the lug L. Frame E is keyed to the semaphore shaft and supports the magnet G. The armature of the magnet is pivoted at M and carries pawl F. Arm B is keyed to the armature and moves with it. Normally, pawl F is in engagement with the cam H so that the arm cannot be cleared. Arm B carries contact blocks at its ends which rest against contact posts D. Through these are carried the circuits for the other arms to be operated by the same up and down rod. When G is energized it raises pawl F into engagement with lug L and at the same time breaks all circuits through D by raising arm B. The signal can now be cleared by movement of the up and down rod. Cam H holds pawl F in engagement with dog L throughout the stroke. A dashpot A is provided to absorb shocks when the arm returns to the stop position. When desired, circuits may also be controlled by the roller contacts K on the semaphore shaft.

The circuits correspond generally to those of the Model 3 and outside connected signals and are as shown in detail for a home, distant and route signal in Figs. 1796-1802, which show the operating, indicating and slot circuits. The slotting of the signal is an accessory that can be omitted if desired. It will be noted that the control of the distant signal is accomplished through a relay rather than by a direct connection to a lever, which is necessary on account of the home movement and distant movement of the mechanism usually being controlled from two separate interlocking plants, and the undesirability of connection between plants, on account of interference in the cross protection circuits, also the distant arm often indicates for the next automatic home signal in advance.

The motor dwarf signal made by the General Railway Signal Company is known as the Model 4 and is shown in Figs. 1803-1806. This signal is, in all essential features, a high signal, in which the counterweight is replaced by a coiled spring shown at A, Fig. 1804.

The dynamic indication is accomplished by the unwinding of a coiled spring driving the motor armature in the reverse direction, the spring being wound up for this purpose during the clearing movement of the signal. The circuit breaker shown at A, Fig. 1805, is arranged to snap over at the end of the clearing movement (the snap break preventing any burning of the contacts) and to return to the normal position (closing the indication circuit) when the arm has gone to the stop position. It is operated by direct connection to a secondary cam mounted on the same shaft as the main driving cam. All shock of overcoming the inertia of the moving parts when signal is returned to normal, is absorbed by a second spring, coiled in the opposite direction, which becomes the indicating spring when a second arm is added, so that the indicating spring for one arm becomes a buffer for the other.

Fig. 1789. Motor Generator Set and Switchboard for Electric Interlocking Plant. Electric Zone, New York Central & Hudson River.

Numbers Refer to List of Names of Parts Below.

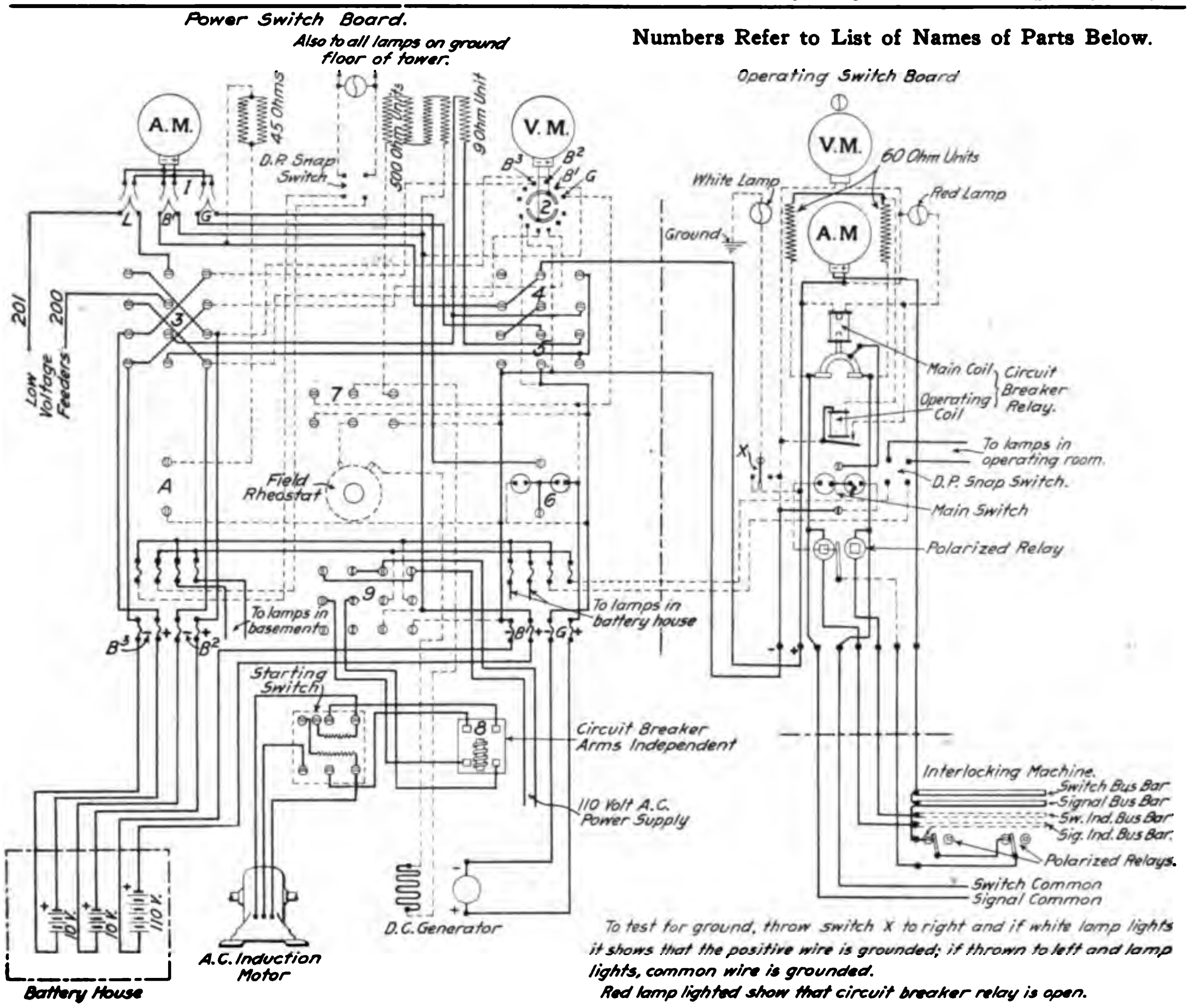


Fig. 1790. Power and Operating Switchboard Circuits for Electric Interlocking Plant. Electric Zone, New York Central & Hudson River.

MANIPULATION.

	Throw Switches.						
To Charge Battery 1	**2G**	**1G**	**7L**	**6U**	**5L**	**4L**	
" " 2	**2G**	**1G**	**7R**	**6U**	**5R**	**3R**	
" " 3	**2G**	**1G**	**7R**	**6U**	**5R**	**3L**	
" " 1 *and* 2	**2G**	**1G**	**7L**	**6U**	**5L**	**4R**	**3R**
" " 1 *and* 3	**2G**	**1G**	**7L**	**6U**	**5L**	**4R**	**3L**
To Serve Int. From Gen.	**2G**	**1G**	**7L**	**6U**	**5L**	**4L**	
" " *Low Voltage Feeders From* **B2**			**3L**				
To Serve Low Voltage Feeders From **B3**			**3R**				
To Serve Lights From A. C.	**9U**						
" " " " *D. C.*	**9D**						

TO START MOTOR.

Throw **9** *Up, Place Starting Switch in Starting Position and Close Switch* **8**; *After Motor is Up to Speed Move Starting Switch to Running Position.*

To Read Voltage of 110-*Volt Battery Hold Switch "A" Closed for* 2 *Minutes and Take the Reading of the Voltmeter at the End of This Time.*

Switch "A" Should Not be Closed While Charging Battery.

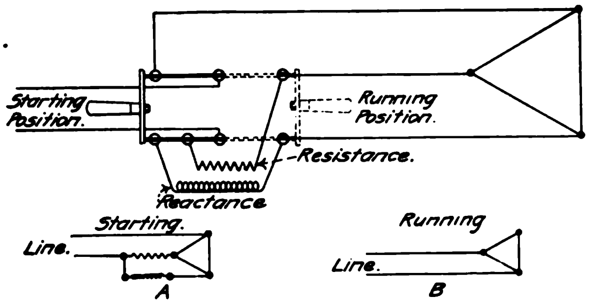


Fig. 1791. Circuits for Starting Switch; Single Phase Induction Motor, Shown in Figs. 1789-1790.

Names of Parts of Power Switchboard, Fig. 1790.

1 *Ammeter Switch*
2 *Voltmeter Switch*
3 *Charging Switch for* 10-*Volt Battery*
4 *Control Switch*
5 *Control Switch*
6 *Under-Load Reverse Current Circuit Breaker*
7 *Field Switch*
8 *Alternating Current Circuit Breaker*
9 *Switch for Power Supply and Lamp Circuit*

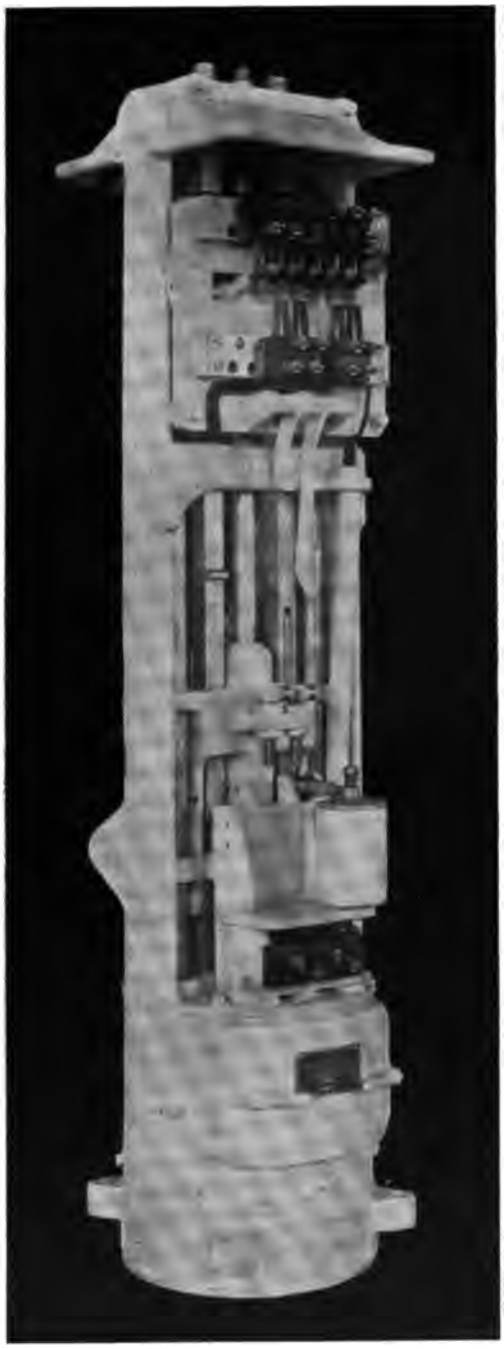


Fig. 1792. Front View, Model 7, Signal Mechanism.

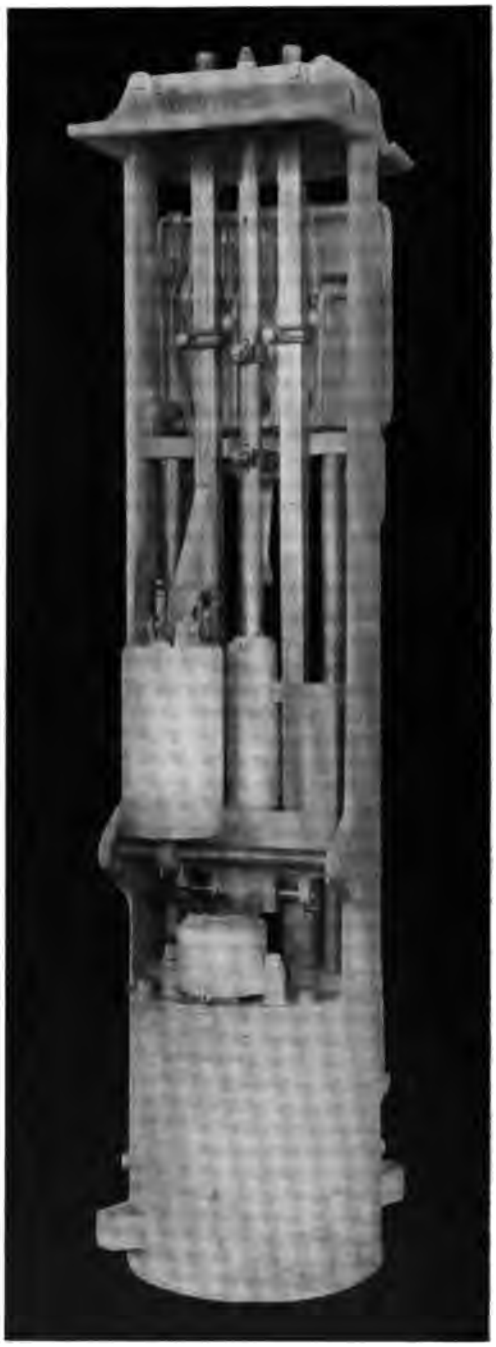


Fig. 1793. Rear View, Model 7, Signal Mechanism.

The movement of the motor is transmitted to the arm through a train of gears and a cam, Fig. 1803. The connection from the cam to the arm is so arranged that the arm is locked by the cam slot at all times except when operated by the motor. A reversible (double field) motor is used, by means of which selection of arms is accomplished.

The circuits as shown in Figs. 1807-1810 for the one-arm, and Fig. 1811 for the two-arm signals, are practically identical with those of the high signal. The heavy lines and arrows show the flow of current in a complete cycle of movement.

The type of electrically driven generator as used in the New York Central Electric Zone work, is shown in Fig. 1789. It consists of a single-phase induction motor direct connected to a shunt wound generator. The motor is supplied (except in the Grand Central Station where 300 volt primary is used) from a 2,200 volt, 25-cycle, single-phase line through static transformers having 110 volt secondaries.

The induction motors have "squirrel cage" armatures and have their fields wound as for a three-phase motor, the winding being connected in delta (Fig. 1791). In the starting position, a non-inductive resistance and a reactance are connected in series with the motor field as shown at A. The resistance and reactance causing a sufficient phase displacement in the windings to set up a distorted revolving field effect, sufficient to give a good starting torque. In the running position, two terminals of the field are direct connected to the line, as shown at B. The change from starting to running positions being accomplished by a double throw switch as indicated.

The regulation of the generator is accomplished by a field rheostat, the switchboard connections being arranged for self-excitation when

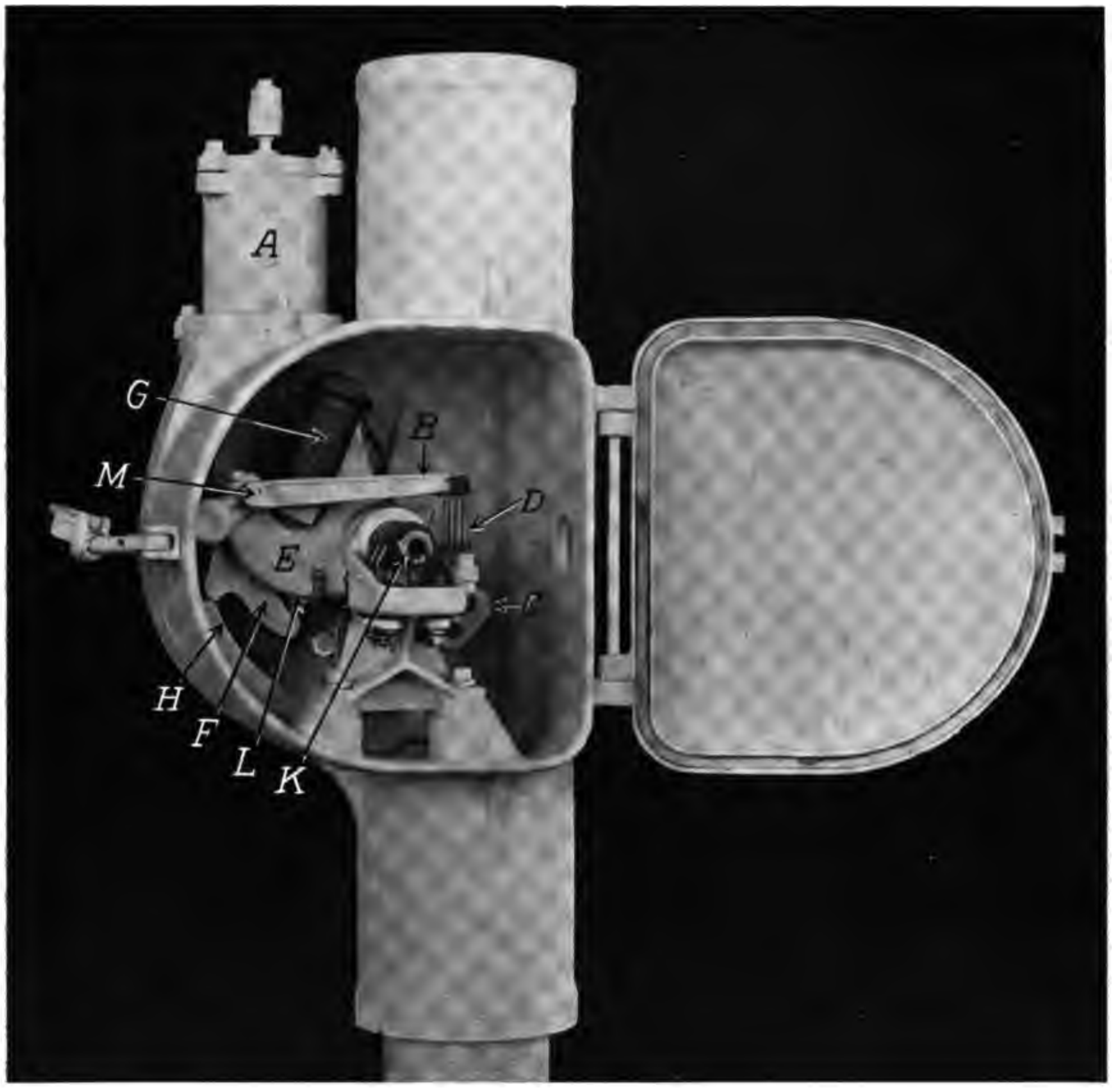


Fig. 1794. Selector Head.

charging the 110 volt battery or the 110 volt and the 10 volt batteries in series, and for separate excitation from the 110 battery if it becomes necessary or desirable to charge the 10 volt battery separately (Fig. 1790). Three sets of batteries are provided; one 110 volt for the interlocking plant proper, and two 10 volt for annunciators, locks, etc.

The power switchboard is equipped with motor starting switch, alternating current circuit breaker, generator field rheostat, fuses, under load-reverse current circuit breaker, and measuring instruments and their switches.

The alternating current circuit breaker is a commercial overload, no-voltage release. The generator field rheostat is of the enameled type, that is, having the resistance covered with enamel, and has a fixed resistance in series when connected for separate excitation of the fields.

Switch A must be held closed two minutes (see note in figure) before taking voltage reading of storage battery. When this switch is closed a current of about 2.5 amp. is taken from the battery through the 45 ohm resistance. This is necessary to eliminate any false difference of potential that may exist across the terminals of the battery due to inaction.

The 500-ohm resistance is used to cut down charging current for the 10-volt batteries.

Rotary switch 2 is for the purpose of reading the voltage of any circuit independently. The under-load, reverse-current circuit breaker is held closed by magnetic attraction only; no latches of any sort being employed. The holding magnets are so designed as to be de-energized if the current reverses. The contacts are large and automatically adjust themselves for a maximum surface of contact.

The operating board controls the supply of current for the interlocking machine by means of the circuit breaker, circuit breaker relay and polarized relay, which automatically cut current off when any cross occurs on an operating wire of sufficient magnitude to cause the improper movement of any function, as explained in connection with Figs. 1772-1773.

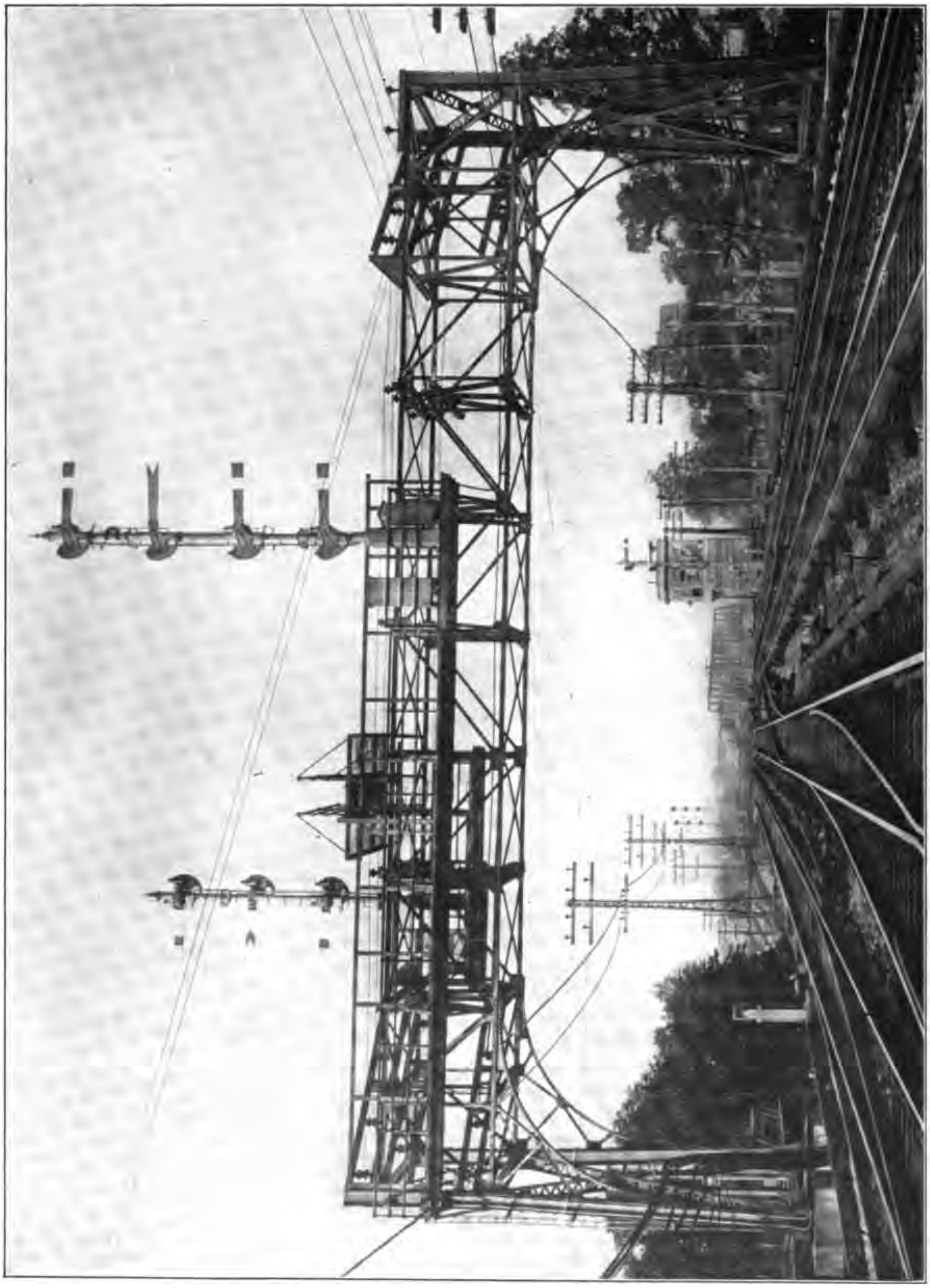


Fig. 1795. Interlocking Plant at Woodlawn Junction. Electric Zone, New York Central & Hudson River.

NOTE.—The special strain bridge shown in the foreground carries the high tension transmission lines, which cross the track at this point, and is also used as a signal bridge. Special protection is provided to keep repairmen working on the signals from coming in contact with the high tension circuits. See also Fig. 2483.

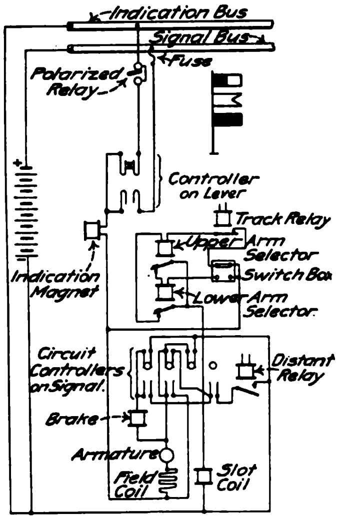


Fig. 1796. Normal.

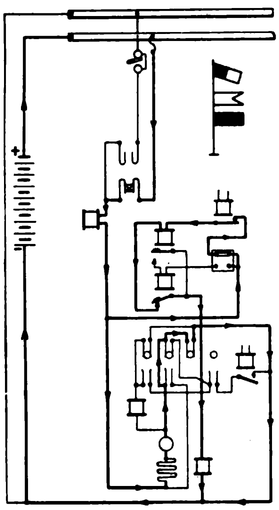


Fig. 1797. Home Signal Clearing.

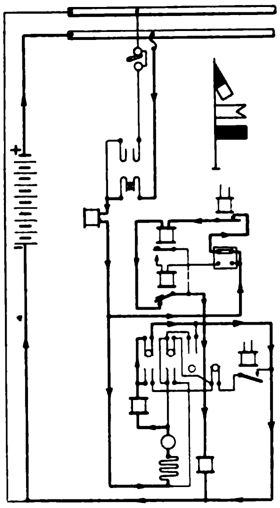


Fig. 1798. Home Signal Clear.

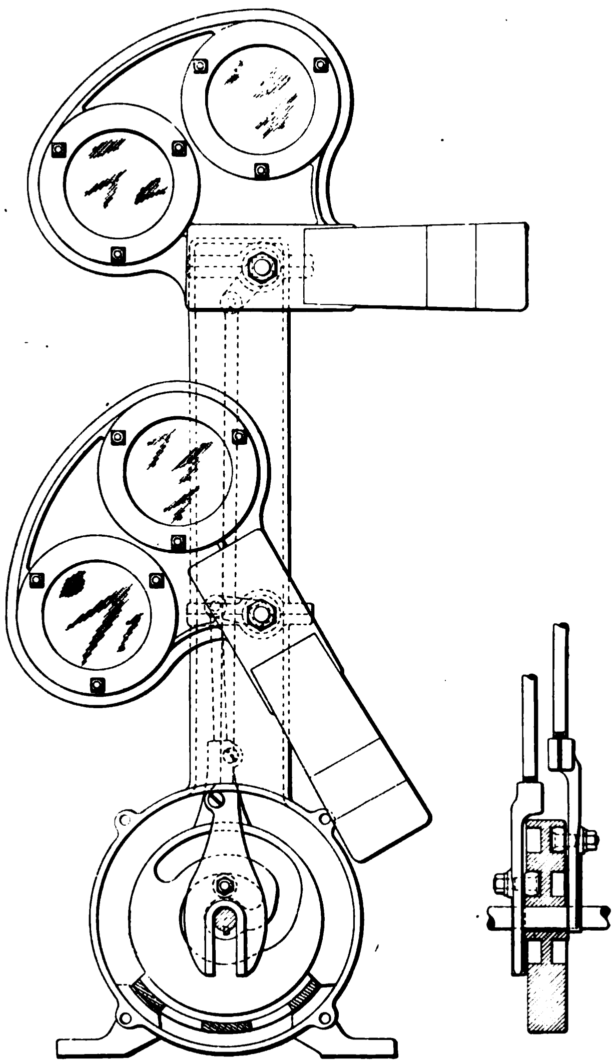


Fig. 1803. Two-Arm Motor Dwarf Signal.

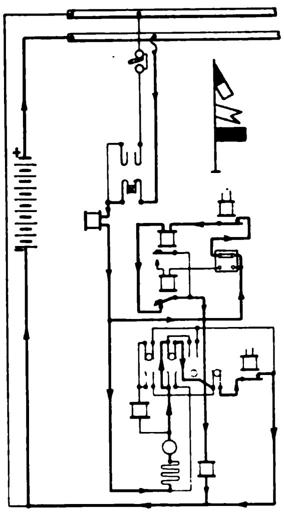


Fig. 1799. Distant Signal Clearing.

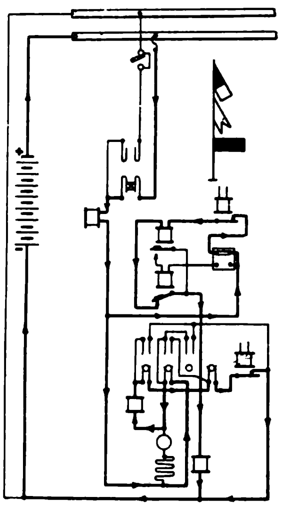


Fig. 1800. Home and Distant Signals Clear.

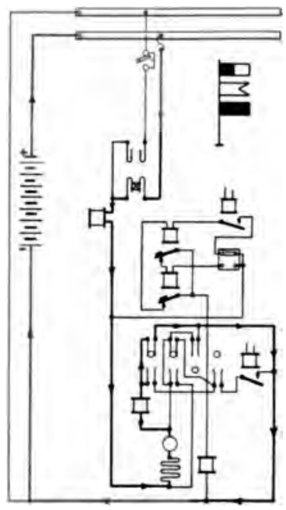


Fig. 1801. Slot Circuit Opened by Track Relay, Restoring Signal to Stop Position.

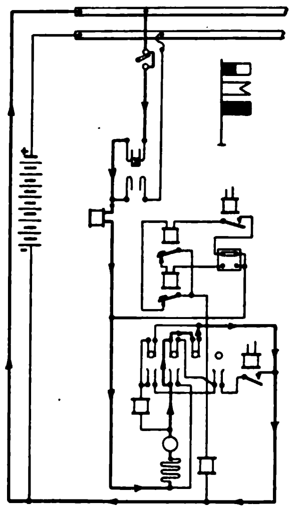


Fig. 1802. Normal Indication.

Figs. 1796-1802. Wiring Diagrams Showing Successive Stages in the Operation of a Model 7 Signal; Home Signal Semi-Automatic.

Fig. 1804. Front View, Two-Arm Motor Dwarf Signal.

Fig. 1805. Rear View, Two-Arm Motor Dwarf Signal.

Fig. 1806. One-Arm Motor Dwarf Signal.

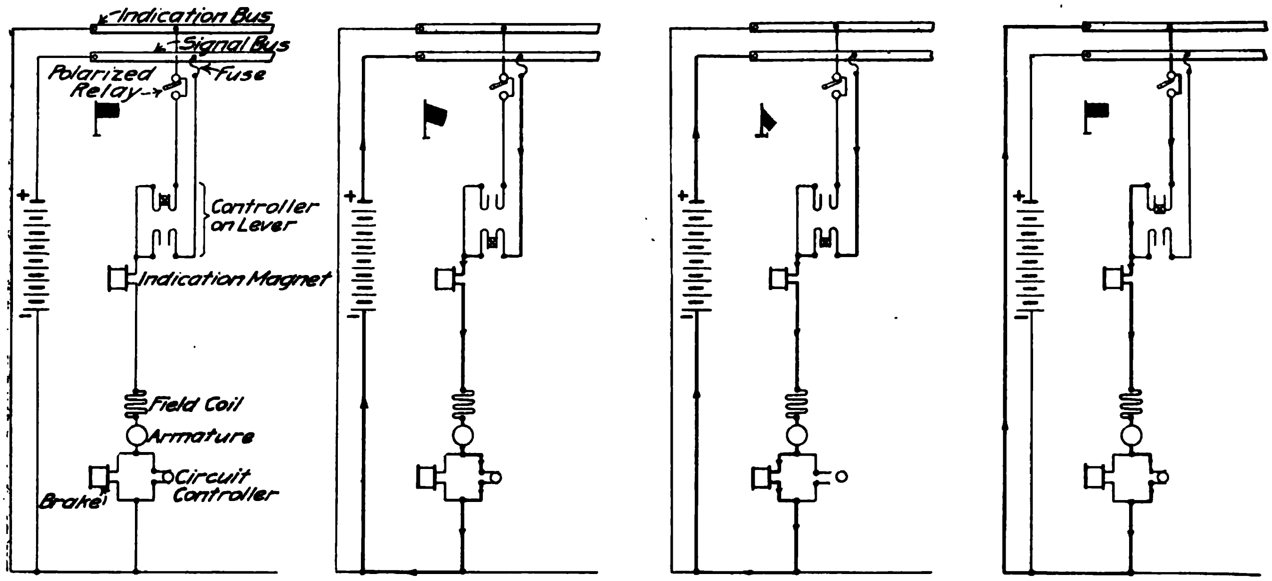


Fig. 1807. Normal. Fig. 1808. Clearing. Fig. 1809. Clear. Fig. 1810. Normal Indication.

Figs. 1807-1810. Wiring Diagram Showing Successive Stages in the Operation of a One-Arm Motor Dwarf Signal.

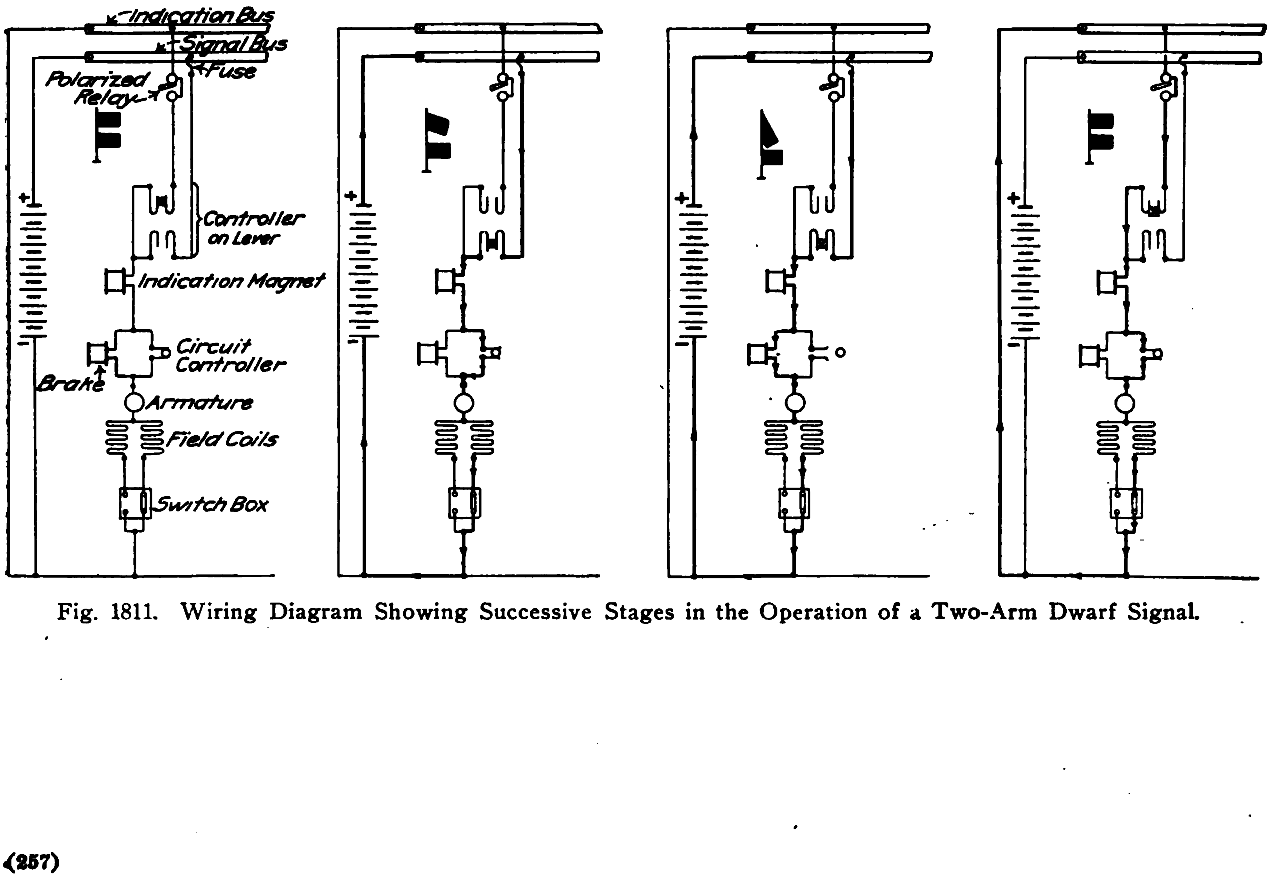


Fig. 1811. Wiring Diagram Showing Successive Stages in the Operation of a Two-Arm Dwarf Signal.

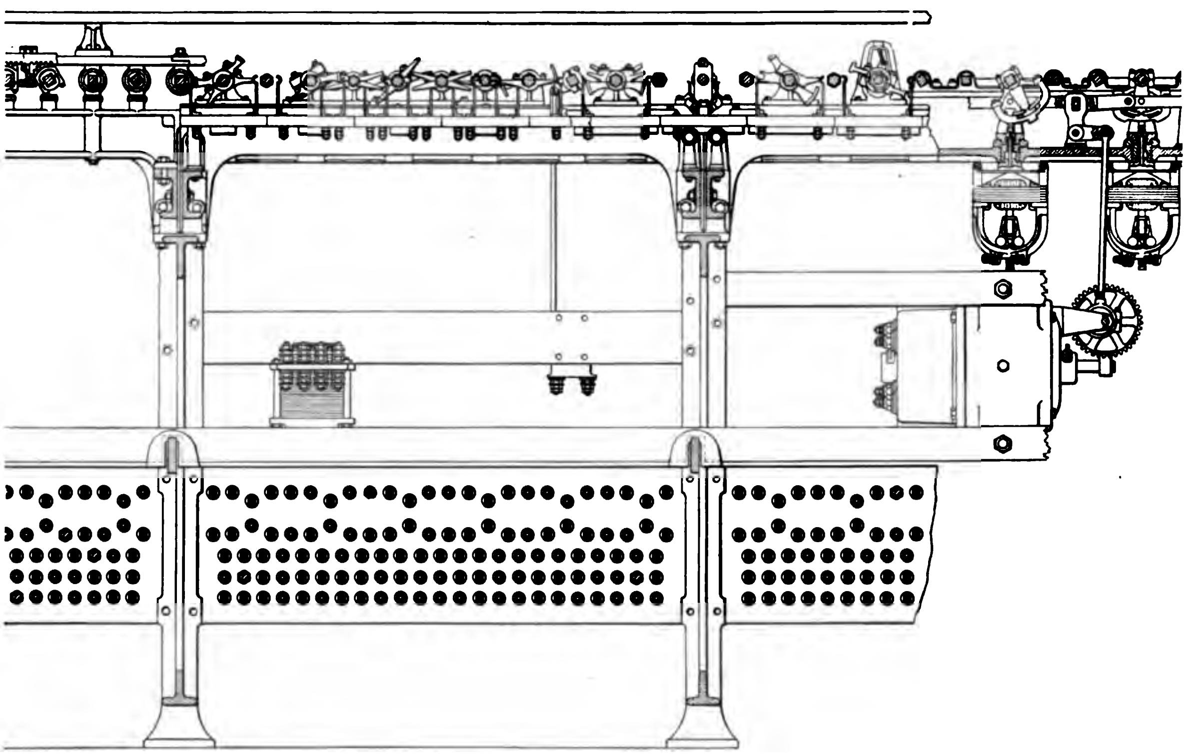
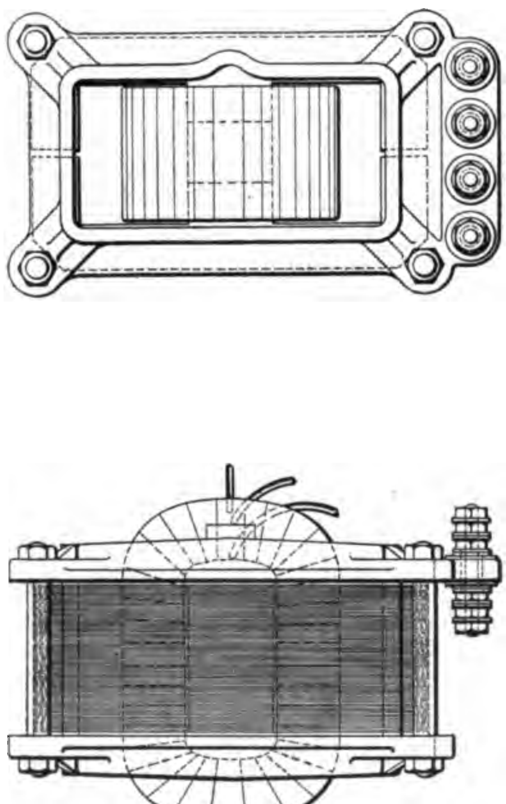
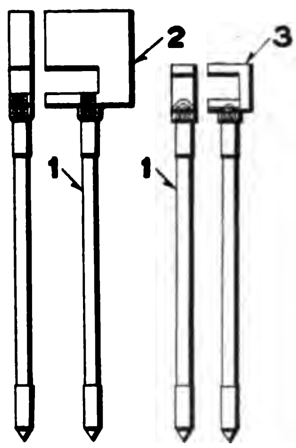


Fig. 1812. Electric Interlocking Machine, View Showing Back Elevation Partly in Section.

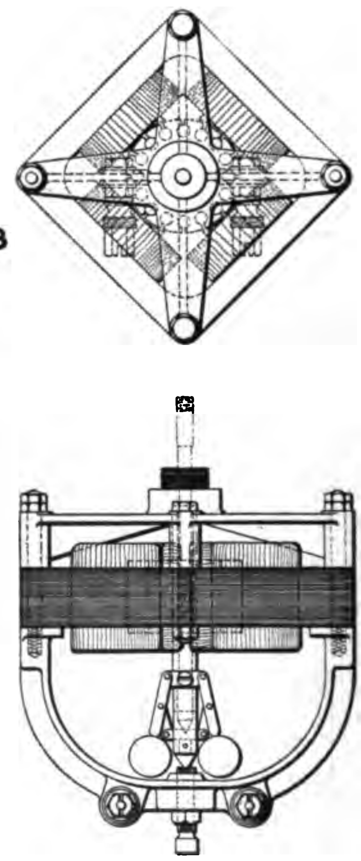


Figs. 1813-1814. Indication Transformer.



Figs. 1815-1818. Indication Latches.

1 *Stem*
2 *Latch for Switch Lever*
3 *Latch for Signal Lever*

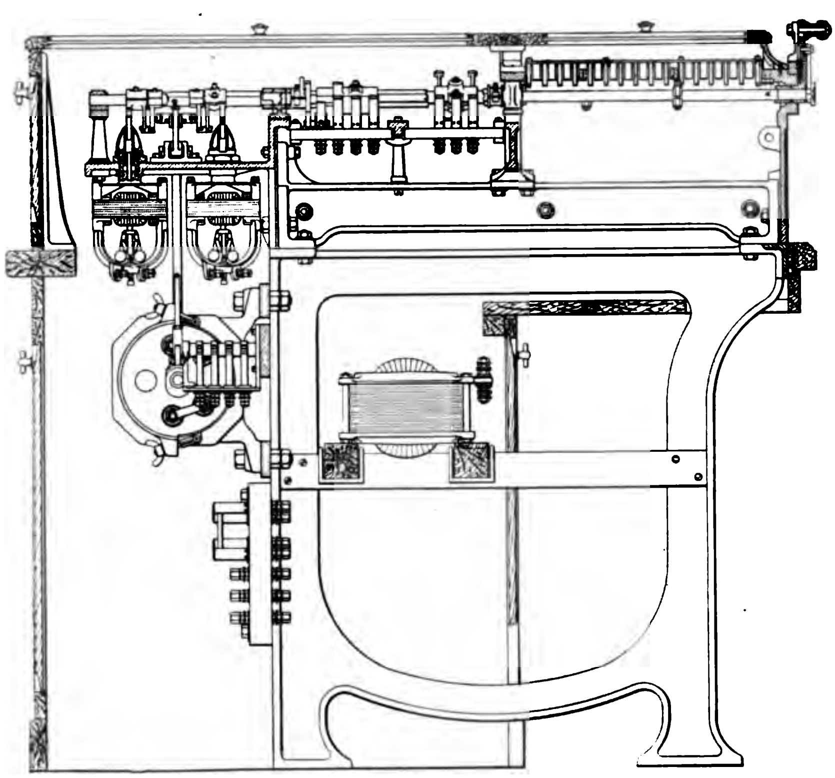


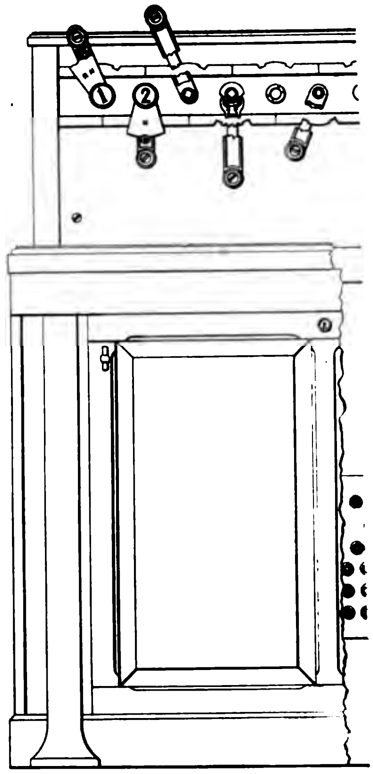
Figs. 1819-1820. Indication Motor.

ELECTRIC INTERLOCKING.

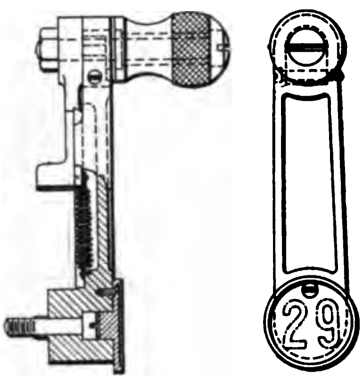
THE UNION SWITCH & SIGNAL COMPANY.

The interlocking machine, an end and a front elevation of which are shown in Figs. 1821-1822, and a rear view in Fig. 1812, resembles very much in general appearance the electro-pneumatic machine, Fig. 1897, and the levers have the same movements. The preliminary movement, limited by the indication latch, effects the locking of all levers whose movements would conflict with the new position of the lever. The final movement, which can take place only after the indication is received, unlocks all levers whose movements would not conflict with that position of the lever. The preliminary movements, in reverse directions, overlap to such



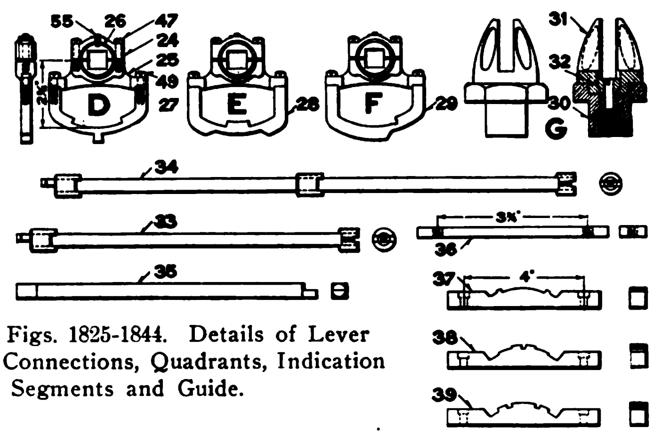


Figs. 1821-1822. Electric Interlocking Machine; Views Showing End Elevation in Section and Front Elevation.



Figs. 1823-1824. Detail of Lever.

Letters and Numbers Refer to List of Names of Parts Below.



Figs. 1825-1844. Details of Lever Connections, Quadrants, Indication Segments and Guide.

an extent as to permit a range of movement sufficient to throw the electric controlling switch from one controlling position to the other at the will of the operator.

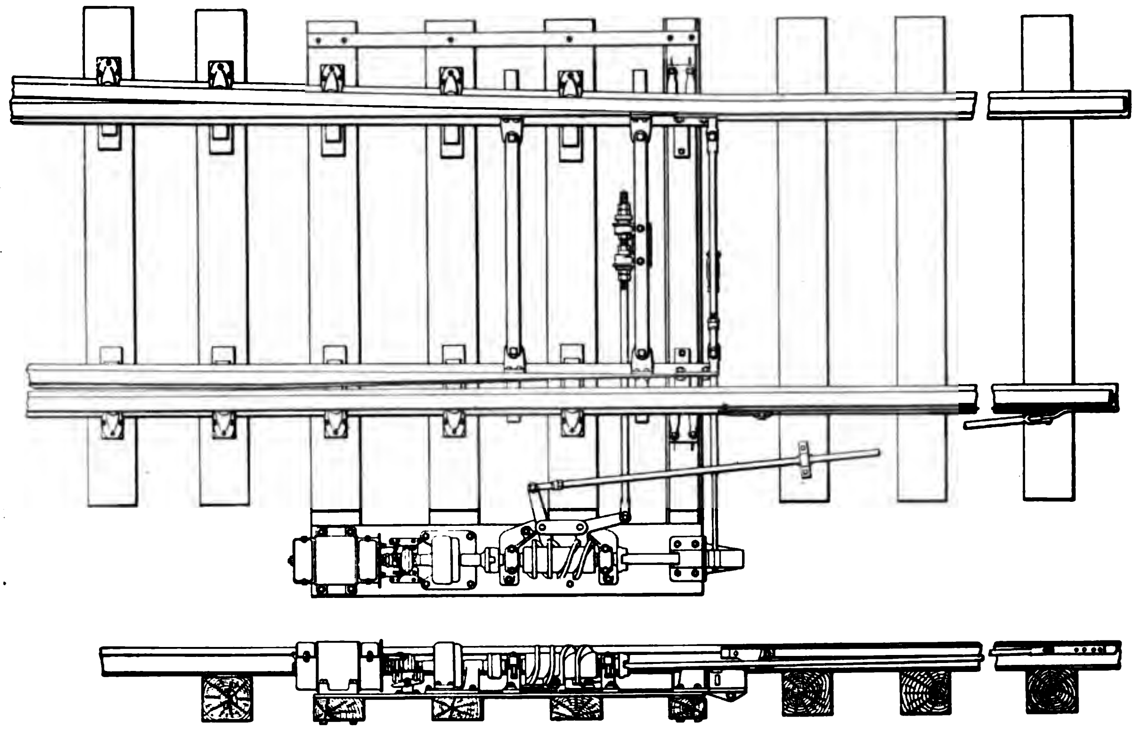
The switch points are made to follow the movements of the lever by sending a current through one or the other of two independent series of field windings on the switch operating motor, which causes rotations in opposite directions. Each independent switch requires one lever, but any two switches which are to be operated simultaneously, as two switches of a crossover, have but one lever.

The signal levers stand normally in the middle position and are moved to the right or left for the purpose of operating opposing signals. Two or more signals, governing diverging routes, are also controlled by one lever when the signals are those operated by one motor, as for instance, when two or three arms are placed on one post. The selection between the arms in this latter case is effected by means of selectors, operated by the switch points themselves, or by the levers which control the movements of the points.

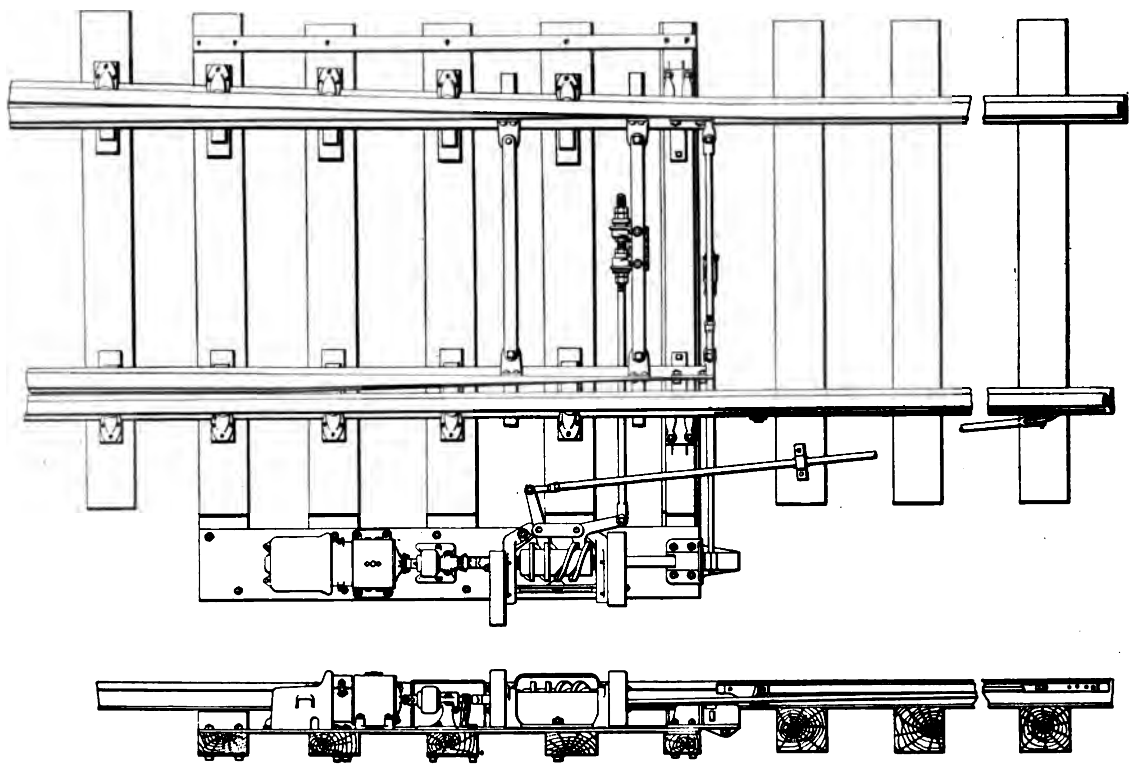
While in the accompanying illustrations the interlocking machine is shown equipped with a stroke completing attachment, it is not customary to apply this device. The stroke completing apparatus comprises a swinging arm, loosely pivoted to each lever shaft, and pawls carried by the frames of the indication segments for engaging these arms. The arms are all connected by means of a bar extending the full length of the machine, and are made

Names of Parts of Figs. 1825-1844.

D *Indication Segment for Switch Lever*
E *Indication Segment for Two-Position Signal Lever*
F *Indication Segment for Three-Position Signal Lever*
G *Guide for Indication Latch and Segment*
24 *Clamp, Upper Half*
25 *Clamp, Lower Half*
26 *Journal for Clamp*
27 *Segment for Switch Lever*
28 *Segment for Two-Position Signal Lever*
29 *Segment for Three-Position Signal Lever*
30 *Guide Base*
31 *Bushing*
32 *Jaw*
33 *Long Lever Shaft*
34 *Short Lever Shafts (2 coupled)*
35 *Indication Segment Shaft*
36 *Strip to Support Slate Base for Circuit Controller*
37 *Quadrant for Switch Lever*
38 *Quadrant for Two-Position Signal Lever*
39 *Quadrant for Three-Position Signal Lever*
47 *Machine Screw*
49 *Machine Screw*
55 *Set Screw*



Figs. 1845-1846. Electric Switch and Lock Movement with Electric Clutch and Planetary Reduction Gear; Views Showing Plan and Side Elevation.

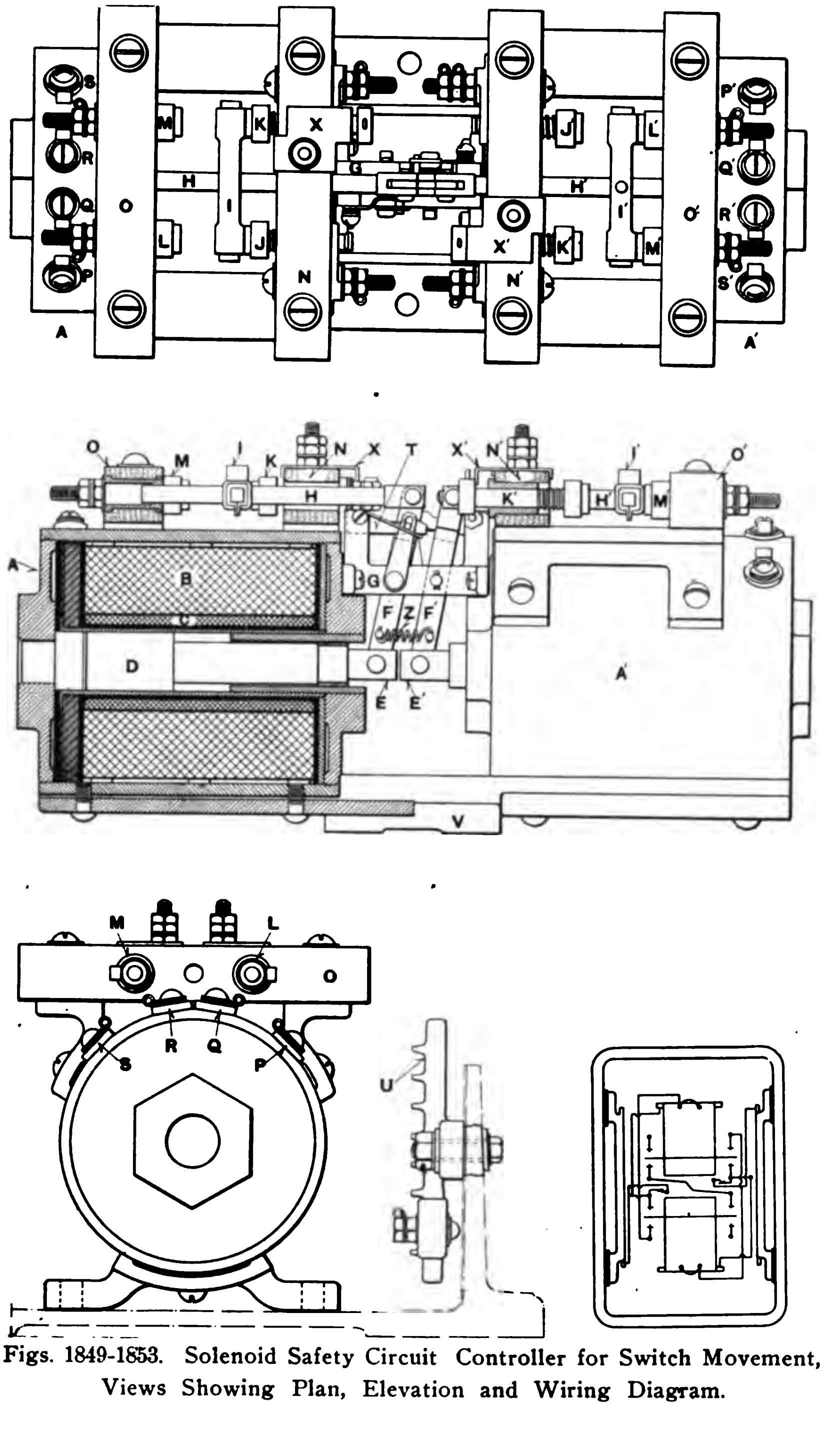


Figs. 1847-1848. Electric Switch and Lock Movement with Countershaft Reduction Gear and Mechanical Clutch.

to oscillate by means of a motor connected to the bar through an eccentric. When an indication is received, the indication latch lifts a pawl into engagement with one of the swinging arms and the lever is thereby rotated through the final part of its movement. The circuit to the motor is controlled by a relay, the exciting coil of which is placed in the main lead between the battery and the machine. Controlled in this way the motor is only in action when required for completing the stroke of a lever.

The indication part of the system is worked in the following manner: The commutator of the motor, in addition to the parts usually found on a direct-current motor, is provided with a collector ring and a brush, bearing thereon. The collector ring is connected electrically with one segment of the commutator. At the end of the movement, the automatic controller changes the

Letters Refer to List of Names Below.



Figs. 1849-1853. Solenoid Safety Circuit Controller for Switch Movement, Views Showing Plan, Elevation and Wiring Diagram.

Names of Parts of Solenoid Circuit Controller; Figs. 1849-1853.

A	*Solenoid*	**M**	*Contact*
B	*High Resistance Coil*	**N**	*Slate Block*
C	*Low Resistance Coil*	**O**	*Slate Block*
D	*Core*	**P**	*Terminal Binding Screws*
E	*Jaw*	**Q**	*Terminal Binding Screws*
F	*Lever*	**R**	*Terminal Binding Screws*
G	*Lever Support*	**S**	*Terminal Binding Screws*
H	*Contact Operating Rod*	**T**	*Latch*
I	*Contact Bridge*	**U**	*Porcelain Resistance Grid*
J	*Contact*	**V**	*Base*
K	*Contact*	**X**	*Contact*
L	*Contact*	**Z**	*Connecting Spring*

path of the current from the operating brush, bearing on the commutator, to the indication brush, bearing on the collector ring, at the same time cutting out the magnetic clutch. The motor then continues to run light, driven by current from the battery, which current is caused to undulate by the varying position of the segment to which the collector ring is attached. This undulating current induces an alternating current in the secondary of a transformer, Figs. 1818-1814, and this alternating current drives a small induction motor, Figs. 1819-1820, which releases the indication latch and permits the completion of the stroke of the lever on the machine. In this manner the indication is brought about by utilizing the battery current which is transformed into an alternating current. The indication motor previously referred to has its armature shaft in a vertical position; to this is attached a piece of centrifugal apparatus very similar in construction to the well known form of governor used on the steam engine. The rapid rotation of the armature causes the weights to separate, and through a combination of levers, to lift the indication latch and release the lever. This mode of construction makes it necessary to have a rapid rotation of the indication motor armature to produce the desired effect, and this rotation can be secured only by a rapid succession of alternating impulses in the coils of the motor. A direct current through these coils has no effect other than to hold the armature against rotation. Single impulses which may be caused by making or breaking a circuit, will cause the armature to move through not more than ten degrees, and a succession of such impulses, following each other as rapidly as it is possible to make and break a circuit by hand, will cause only a step by step movement of the armature, the armature coming to a full stop at the end of each step, so that impulses produced in this manner will not cause the weights to move from their position of rest against the armature shaft.

Fig. 1845 is a plan and Fig. 1846 a side elevation, showing a switch and its operating mechanism. The switch and lock movement is driven by a direct current motor of about 1½ h.p., designed to be operated at 110 volts. The shaft of this motor is connected by means of a magnetic clutch to a shaft extension in the same line, working a cam drum, which operates the switch and lock. Intermediate between the magnetic clutch and drum, there is a reduction gearing with a speed ratio of 25 to 1. There are two cams on the drum, one of these working the lock rod and detector bar, and the other the switch, connection being made to the detector bar and switch through cranks. The lock is worked direct by a straight bar which slides longitudinally beneath the cam, motion being imparted by means of a lug fitting the cam slot. In each case the cam slot, for a portion of its travel, moves in a plane at right angles to the shaft, so that while that portion is passing the lug on the driving bar or crank, no movement of the latter takes place; it is only while the lug is engaged by the diagonal portion of this slot, that movement is imparted to the switch or lock mechanisms. The operation is as follows: When the drum is revolved by the motor, the lock rod and detector bar immediately begins to move, and as soon as these have completed part of their stroke, their motion ceases and the movement of the switch begins. After the switch has been moved over against the stock rail, further motion of the lock bar locks the switch and at the same time operates a knife switch which opens the control circuits and closes the indication circuit. The cam drum is reversible, so that the movement can be operated either right or left (the position of the motor and clutch remaining the same) by changing the drum, end for end. The motor, clutch and drum are all attached to a steel base plate. The direction of rotation for reversing the

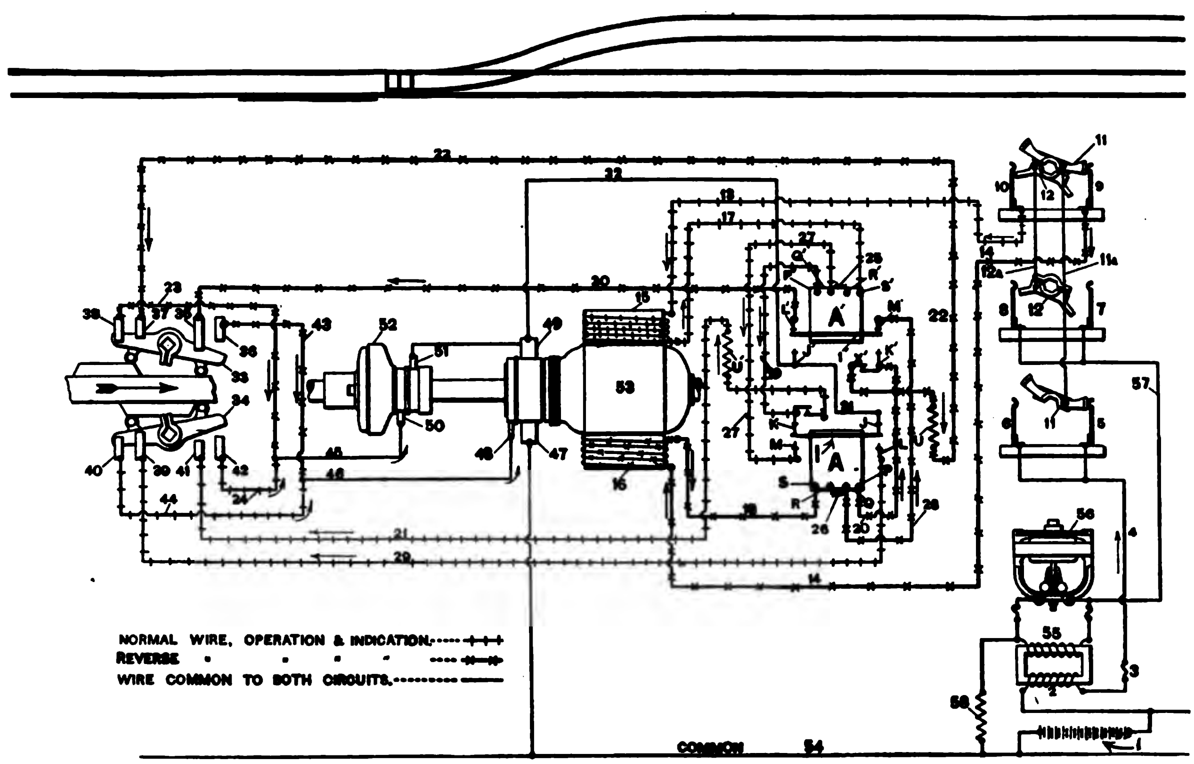


Fig. 1854. Control and Indication Circuits for a Single Switch; Beginning of Reverse Movement.

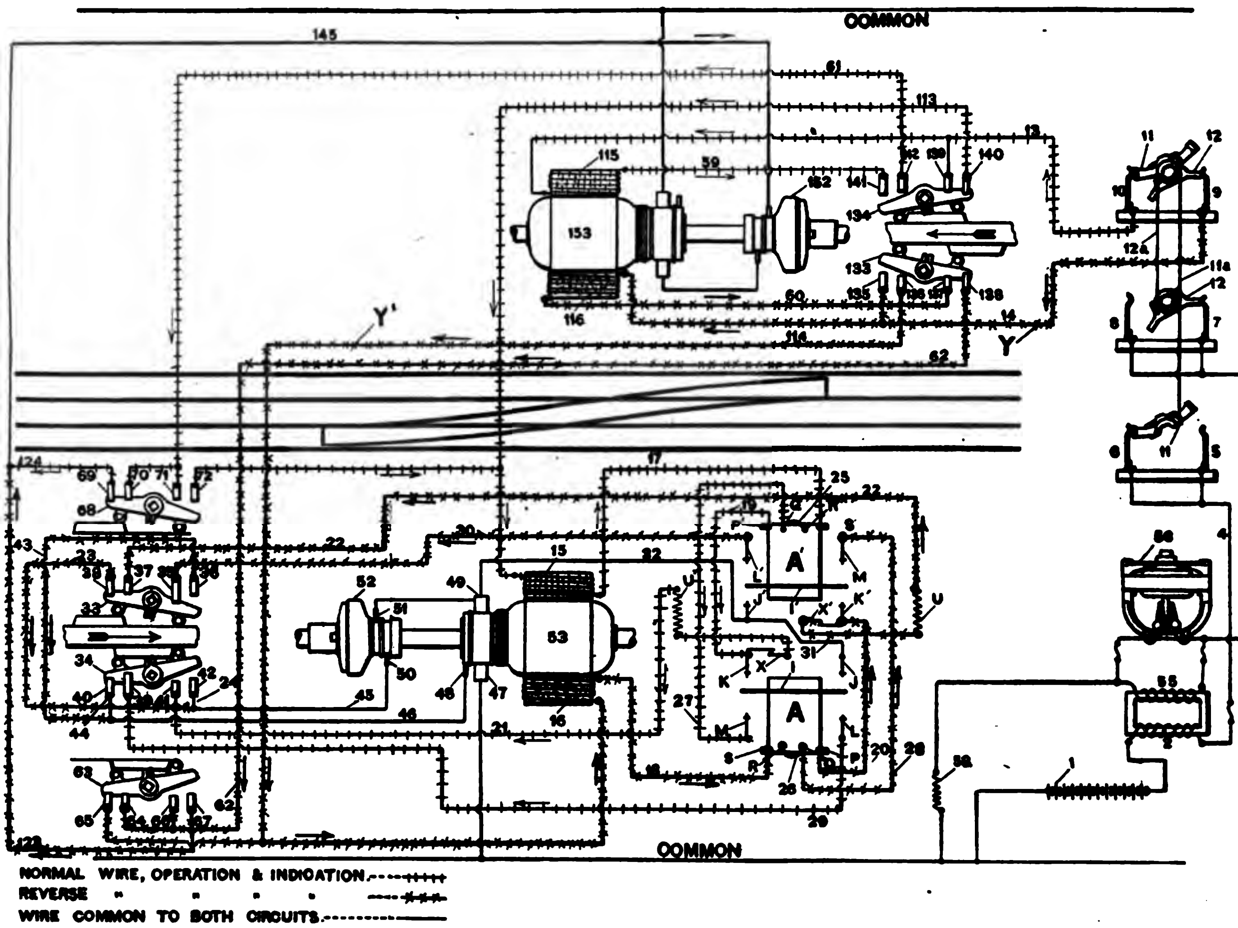


Fig. 1855. Operating Circuits for Crossover; All Parts in Normal Position.

switch is controlled by means of two field windings, one of which is cut out while the other is in circuit. When the switch is to be thrown in the reverse direction, the lever on the interlocking machine merely changes the connection of the operating circuit to the other field winding.

The magnetic clutch permits of breaking the motor connection with the throwing mechanism at the proper time; and the absence of a rigid connection prevents breaking or straining of the parts if the movement of the switch should become blocked, the blocking of the switch merely causing the clutch to slip until a fuse is blown on the interlocking machine. If the switch is found to be blocked, it can be thrown back by simply reversing the lever, and this can be done quickly enough to avoid blowing the fuse.

Figs. 1847-1848 show this type of switch and lock movement

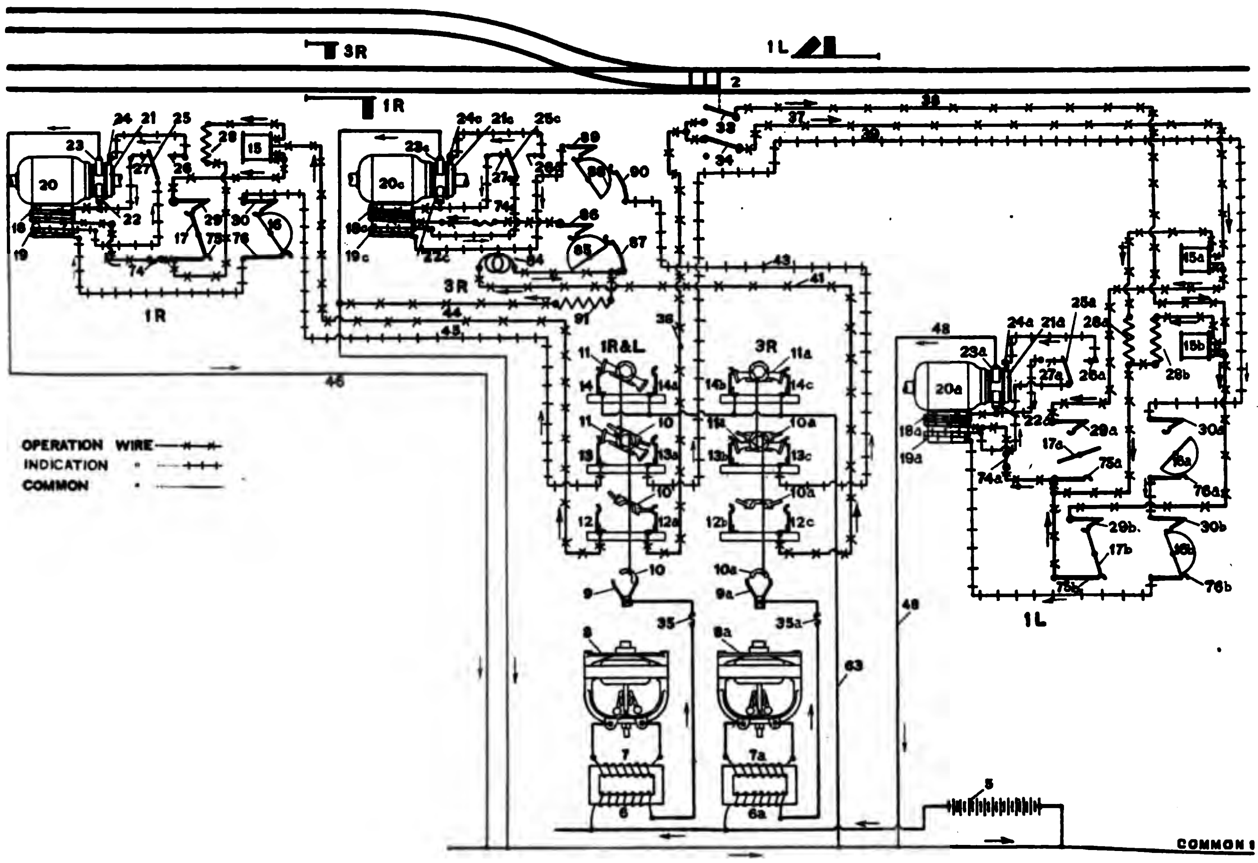


Fig. 1856. Control and Indication Circuits for Electric Interlocking Signals.

provided with a countershaft reduction gear and also a mechanical clutch instead of the electro-magnetic clutch just described.

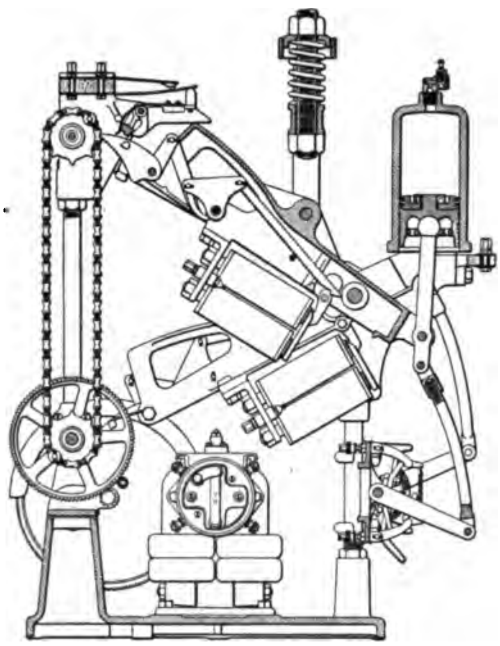
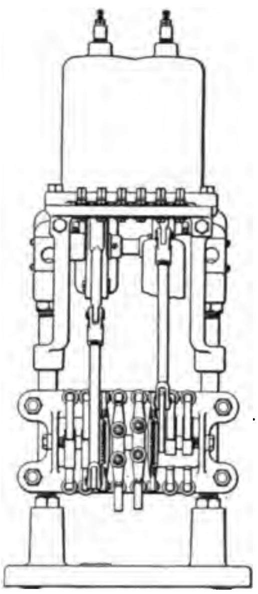
The safety controller, which automatically cuts out a switch motor if the wires become improperly connected, combines in one, the functions of two electro-magnetic circuit controllers. The function of one is to open the motor circuit when the lever movement is completed, and of the other to open the next operating circuit when it is energized improperly by connected wires, and thus to prevent a wrong movement. The instrument which is illustrated in Figs. 1849-1853, comprises two solenoids A and A', fixed to a cast iron base V. Each solenoid has a movable core D, connected by means of a jaw E to a lever F. The lever F is pivoted at its middle to a fixed support G and is connected at its upper end to a rod H, free to move longitudinally. The rod H carries a contact bridge I, which will connect the contacts J and K when the core D is drawn into the solenoid, and will connect the contacts L and M when the core D is drawn outward. The levers F and F' are connected near the lower ends by a spring Z, which causes the bridge I' to connect L' and M', when the core D is drawn into its solenoid A to nearly the full extent. Similarly the contact bridge I is made to connect L and M when the core D' is drawn into the solenoid A'. The contacts J and K are carried by the slate block N, with springs interposed so that they may be pushed in about 3-16 inch. The contacts L and M are fixed to the slate block O. The relation of the parts is such, that the bridge I touches the contacts J and K, while the core D is still 3-16 inch from its complete inward stroke, and the bridge I' touches L' and M' with the core D about 1-16 inch from its full inward stroke. These clearances are allowed for making good contact. Each solenoid has two coils of wire. The coil C has 100 turns of No. 18 B. & S. and the coil B 1100 turns of No. 15 B. & S. The resistance U and U', each of twenty ohms, are in series with the coils B and B' at the starting of a movement, and the circuits including them may be called the starting circuits. The coil B is connected to terminals P and Q, and the coil C is connected to terminals R and S.

At the beginning of a movement, current flows through coils C and B, and resistance U in series, and draws in the core D, causing the bridge I' to connect L' and M', which shunts the coils B and U, so that the operating and indicating currents flow only through the coil C, of a very low resistance, but having sufficient turns to hold the core D in place. The bridge I will touch J and K before I' touches L' and M', so that if the current happened to come from a foreign source without the lever having been moved, current would also flow from the last operating wire, which is still in connection with battery, through coils C', B', bridge I, and the motor, and would hold I' away from L' and M', by drawing in the core D'. This current will run the motor light in the direction it ran in making the last movement without energizing the clutch. The contact K is provided with a head on its inner end, which makes connection with a contact X, when K is pushed outward by the spring, but when K is pushed in by the bridge I, it is separated from X. The object of this is to cause the cut-off current to flow only through the safety contacts J and K, and thus afford a test of their condition at each movement of the switch.

When the core D is drawn completely into the solenoid A, the latch T drops into the path of a projection on the lever F', so that if the magnet A' is energized while A is still holding its core, the core D' will be stopped by the latch T before it puts the bridge I' against J' and K'. A similar latch, T', stops the core D under similar conditions. These latches come into play in the action of the cut off current last above mentioned. If in that case the bridge I' were allowed to move far enough to touch J' and K', the safety circuit to be mentioned later would be temporarily closed and cause sparking at the contacts.

The circuits of a single switch can be understood from an inspection of Fig. 1854. In the position of the parts as shown, which is the beginning of the reverse movement, current will flow from battery 1 through primary 2, fuse 3, wire 4, spring 5, bridge 11 (11, 11a and 11 are one piece on machine), spring 9, wire 14, field 16, wire 18, coil C of A, connector 26, coil B of A, wire 20, contacts K' and X', resistance U, wire 22, contacts 37 and 38 of knife switch 33, wires 23 and 45, clutch 52 by brushes 50 and 51, armature 53 by brushes 49 and 47, thence by common wire to battery. This current will energize the magnet A, the bridge I will connect J and K, and the bridge I' will connect L' and M'. The above circuit remains the same up to wire 18, thence through coil C of A, wire 28, contact M', bridge I', contact L', wire 30, contact 35, knife 33, contact 38, to wire 23, whence it is the same as above. The current in the coil C holds the core D and the bridges I and I' in position last noted.

When the switch movement is completed, the knife 33 is moved from contact 38 to contact 36, still remaining in contact with 35. This cuts off the current from the clutch 52, and causes it to flow through wires 43 and 46, indication brush 48, armature 53, brush 47, and common to battery. The current still flows through the coil C, thus holding I and I' in positions noted. The current entering the armature 53, by the way of the brush 48, which bears on a ring connected to a segment of the commutator, is thereby

Figs. 1857-1858. Style "B" High Signal Mechanism, Adapted to Electric Interlocking.

rendered pulsating in character. In flowing through the primary 2 of the transformer, it develops magnetism of a like character in the iron core. This in turn induces alternating current in the secondary coil 55, which flows through the induction motor 56, by means of which the latch is lifted, thus relasing the lever to make its final movement.

The final movement of the lever puts the bridge 12 in contact with spring contacts 8 and 10, which closes a branch circuit, and current flows from armature 53 by way of brush 49, wires 32 and 31, contact J, bridge I, contact K, wire 19, coil B' of A', connector 25, coil C' of A', wire 17, field 15, wire 13, spring 10, bridge 12, spring 8, wire 57, motor 56, and secondary 55 in parallel, and resistance 58 to battery. This current energizes magnet A', draws in its core D', and pulls the bridge I' away from contacts L' and M', thus cutting off all current.

Fig. 1855 shows a crossover with all parts in normal position. To reverse the crossover, the bridge 11 will be moved by the lever to connect the contacts 5 and 9, when current will flow from battery 1 through 2, 3, 4, 5, 11, 9, 14, field 116, wire 60, contacts 137 and 138 of knife switch, wire 62, contacts 64 and 65 of knife switch, field 16, wire 18, coil C of A, connector 26, coil B of A, wire 20, contacts K' and X', resistance U, wire 22, contacts 37 and 38 of knife switch, wires 23 and 45, clutch 52, armature 53, thence through common to battery. This current energizes magnet A, thereby causing the bridge I to connect J and K, and bridge I' to connect L' and M'. The connection of L' and M' shunts the coil B and resistance U out of the motor circuit, as explained in connection with the single switch. When the mechanism connected to armature 53 has moved a short distance, the knife switch 63 is shifted from contacts 64 and 65, to contacts 66 and 67, which breaks the circuit through armature 53, and continues the circuit from wire 62 through contacts 66 and 67, wires 123 and 145, clutch 152, armature 153, thence through common to battery. The switch operated by motor 153 then makes its complete movement, at the end of which, the knife 133 is shifted from contacts 137 and 138 to contacts 135 and 136, which stops the current through field 116 and armature 153, and continues the circuit from wire 14 through contacts 135 and 136, wire 114 to field 16, thence it is the same as that above traced, which caused the preliminary movement of the mechanism operated by armature 53. The current in this last circuit causes the armature 53 to complete the movement, and indicate, which it does as explained in the description of the single switch.

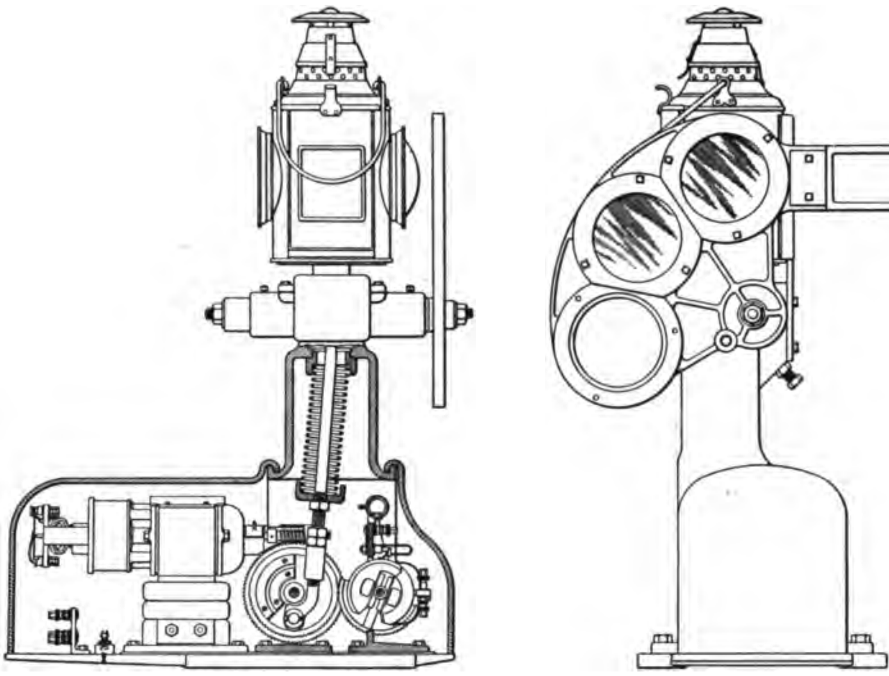
The action of the crossover mechanism may be briefly stated as follows: The armature 53, which is governed by the safety controller starts the movement, and after a short preliminary movement, opens its own circuit, and closes that of 153. Armature 153 then completes its movement, and again closes the circuit to 53, which then completes its movement, and indicates.

To explain the action of the safety controller, in protecting against stray currents, reference will be made to Fig. 1855, which shows a lever in complete normal position. Suppose a live wire to be connected with wire 14 at Y. Current would flow through the magnet A, just the same as though the lever had been reversed. This would cause the bridge I to touch J and K, when a circuit would be closed and current would flow from battery 1, through 2, 3, 4, 6, 11, 10, 13, contacts 139 and 140, wire 113, field 15, wire 17, coils C' and B' of A', 19, K, I, J, 31, 32, armature 53 by brushes 49 and 47, to common. This current would energize magnet A', and would hold the bridge I' away from the contacts L' and M'. It would also turn the armature 53 in the direction it ran in making the last movement, because the current goes through the same field 15 that was then used. The rotation of the armature produces a back E. M. F., which limits the current to such a small amount that there is no danger of burning out the magnet A'. This condition would continue as long as the fault remained. When this is removed, the apparatus replaces itself in proper condition for use. If the contact had occurred at Y' on wire 114, the action would be the same.

For high signals, use is made of the ordinary Style "B" electric semaphore, Figs. 419-428, with the addition of a third brush to the motor, to give the indication in a manner similar to that described for the switch machine, with other slight changes made necessary by the use of a higher voltage. The high signal mechanism is illustrated in Figs. 1857-1858.

The dwarf signal, Figs. 1859-1860, is actuated by an electric motor, similar in all respects to that used in connection with the high signals. The motor drives, by means of a worm gear, a horizontal shaft to which the armature of an electro-magnetic clutch is fixed. The other part of the clutch, enclosing the exciting coil is fitted loosely on the shaft. This loose part of the clutch has a crank pin affixed, to which the operating rod of the signal is attached. When the signal is at normal or stop position, the crank pin is vertically under the shaft; when clear, the crank pin is about 45 degrees above the horizontal. The exciting coil of the clutch is connected in series with the motor, and when energized by the operating current, both the motor and clutch are excited, the first causing the clutch armature to rotate, and the second causing the loose part of the clutch to adhere to the armature and move with it. When the signal reaches the clear position, a circuit switch cuts in sufficient resistance to reduce the holding clear current to a very small amount and to stop the motor. The dwarf signal is locked in the normal position by means of a hook-shaped formation on the eye of the operating rod, which engages with the shaft carrying the clutch, if the rod is moved upwardly a very short distance. Sufficient lost motion is allowed in the crank pin hole to permit a slight upward movement of the rod without turning the clutch.

The signals are protected against improper movements due to stray currents, by means of a fuse placed in the signal operating circuit between the slot coil and the motor. When the signal lever is in the normal position, the indication wire is connected to the common wire, and as the indication wire is also connected to the control wire at the signal motor, both being connected to the same brush on the armature, a current which might reach the control wire would be short circuited back to battery through the indication wire, and would cause a very heavy current to flow and blow the fuse in the operating circuit, thus cutting off current



Figs. 1859-1860. Motor Dwarf Signal.

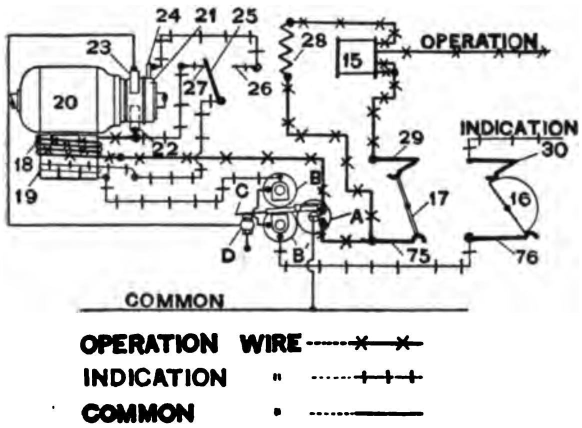


Fig. 1861. Dwarf Signal Circuits.

from the signal motor and preventing a false movement. If a contact with a foreign source should occur beyond the fuse, it would also be beyond the slot, so that the slot magnet would not be energized and the signal would not clear. The same arrangement is followed in reference to the safety controller in connection with the switch motor. The coils of the magnets referred to are both placed between the field coils of the motor and the armature, so that if the contact should occur beyond these protecting magnets, it would also be beyond the field magnet coils, and consequently in this case the field magnets would not be energized so that the armature would not rotate.

Fig. 1856 shows the arrangement of signals at a turnout from a main track. The two high signals are operated by lever 1, the single arm signal in the right hand position of the lever, and the double arm in the left hand position. Selection between the two arms of the high signal is effected by the switch box on switch 2. The dwarf signal is controlled by lever 3 in its right hand position. Lever 1 is shown reversed to the left, and upper arm of 1-L is clear. The current for clearing this signal flows from battery 5, through primary 6 of indication transformer, fuse 35, switch 9, contacts 10 and 12a, wire 36, contact 34, wire 37, series slot coil of 15a, contacts 29a, 17a, 75a, fuse 74a, field coil 18a, brush 22a, armature of signal operating motor, brush 23a, wire 48, to common. When the signal is clear, the contact 17a is separated from 29a and 75a, but this break is shunted by the shunt coil of slot magnet 15a, and the resistance 28a, which permits only a small current to flow, but sufficient to hold the signal clear. To put the signal normal, the lever is moved toward normal position until stopped by the indication latch, in which position 10 makes contact with 13a, but is separated from 12a. The separation of 10 and 12a breaks the circuit through the holding coil of the slot magnet, and allows the signal to go to normal position. When the signal is normal, 16a makes contact with 30a, and completes a circuit so that current flows from battery 5 through primary 6, fuse 35, switch 9, contacts 10 and 13a, wire 39, contacts 30a, 16a, 76a, 30b, 16b, 76b, field coil 19a, tongue 25a of centrifugal controller, contact 27a, brush 22a, armature of signal motor, brush 23a, and wire 48, to common. This causes the signal motor armature to rotate, and when it has acquired sufficient speed, the tongue 25a is moved over to the contact 26a, when the current will enter the armature through the brush 24a and collector ring 21a, instead of the brush 22a. This causes the current to undulate and produces undulating magnetism in the core of the transformer, thereby inducing an alternating current in the secondary coil 7 of the indication transformer, which flows through the coils of the indication motor 8, lifts the latch by means of centrifugal action and releases the lever, permitting it to be put in normal position.

If the switch 2 had been reversed, the contact arm 33 instead of 34, would have been in contact with control wire 36, and the current would have passed from wire 36 through contact 33, wire 38, slot magnet 15b, and contacts 29b, 17b and 75b. This would have cleared the lower arm. The circuits for the single arm high signal, and the dwarf signal are in every respect similar to those just described. The clutch 84 of the dwarf signal replaces the slot magnet 15 of the high signal.

Fig. 1861 illustrates a safety controller for signals, intended to take the place of the fuse 74. It is superior to the fuse in some respects, as it replaces itself ready for operation when the fault is removed, and is independent of the strength of current. Of course a certain minimum current is required to operate it, but this minimum need not be greater than the signal operating current, as is the case with the fuse. It is similar in general appearance and mode of operation to the common polarized relay, but has no permanent magnet. The permanent magnet of the common polarized relay is replaced in this instrument by the single spool electro-magnet A. The double electro-magnet B—B' is the usual electro-magnet of the polarized relay. To move the armature, therefore, requires current in both A and B—B', and these two currents must flow in a certain direction relatively to each other. The signal control circuit is taken through the magnet A, the indication circuit through magnet B—B', and the connection of the signal motor to common, goes through the contacts C and D, controlled by the relay. When the signal is operating, current flows only in A, when it is indicating, the current flows only in B—B', and in neither case is any effect produced on the armature which remains stationary, holding the common return circuit closed. When the signal lever is normal the indication wire is connected to common at the lever. If then a live wire should make contact with the control wire, a current would flow through slot magnet 15, contacts 29 and 75, magnet A, field coil 18, contacts 27 and 25, field coil 19, magnet B—B', contacts 76 and 30, thence through indication wire to common. This would energize both magnets A and B—B', and the connections are so arranged that the direction of flow is right to move the armature C away from the contact D, and thus open the motor return circuit. This condition would be maintained until the fault is removed, when the armature would replace itself in contact with D.

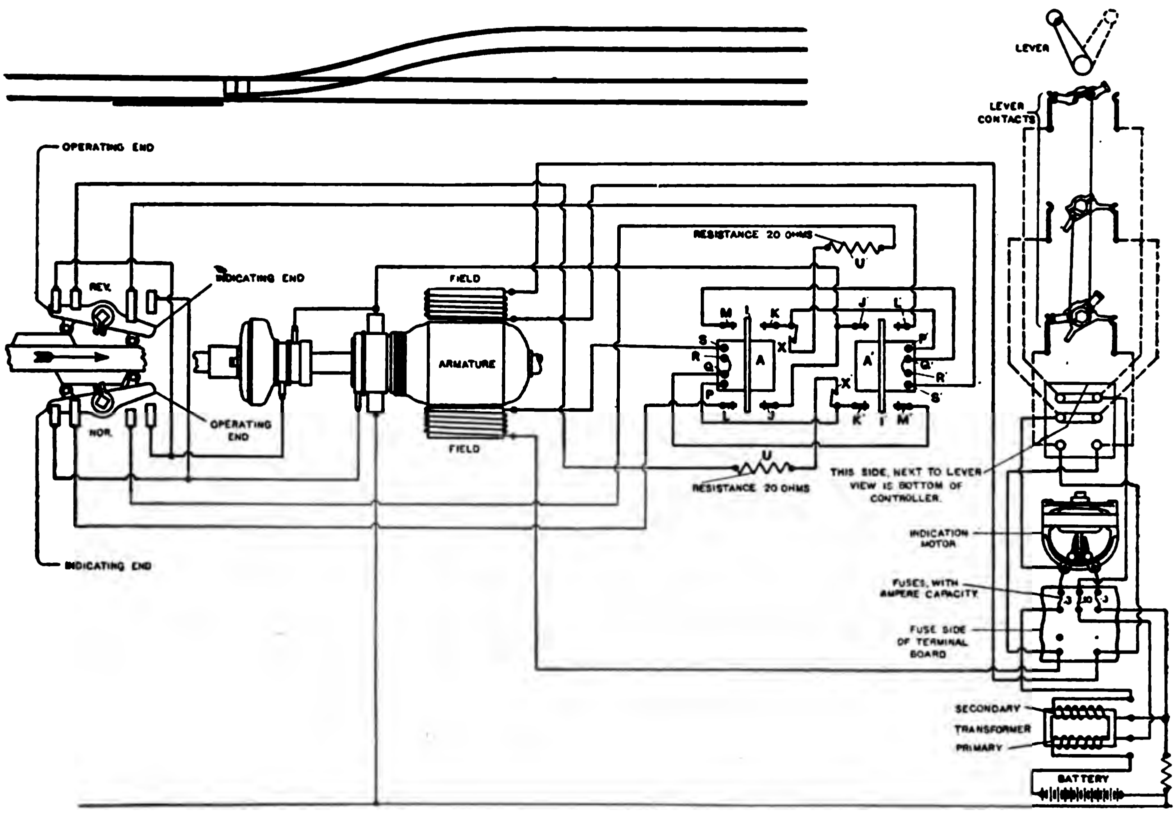


Fig. 1862. Circuits for Single Switch; Lever and Switch Normal.

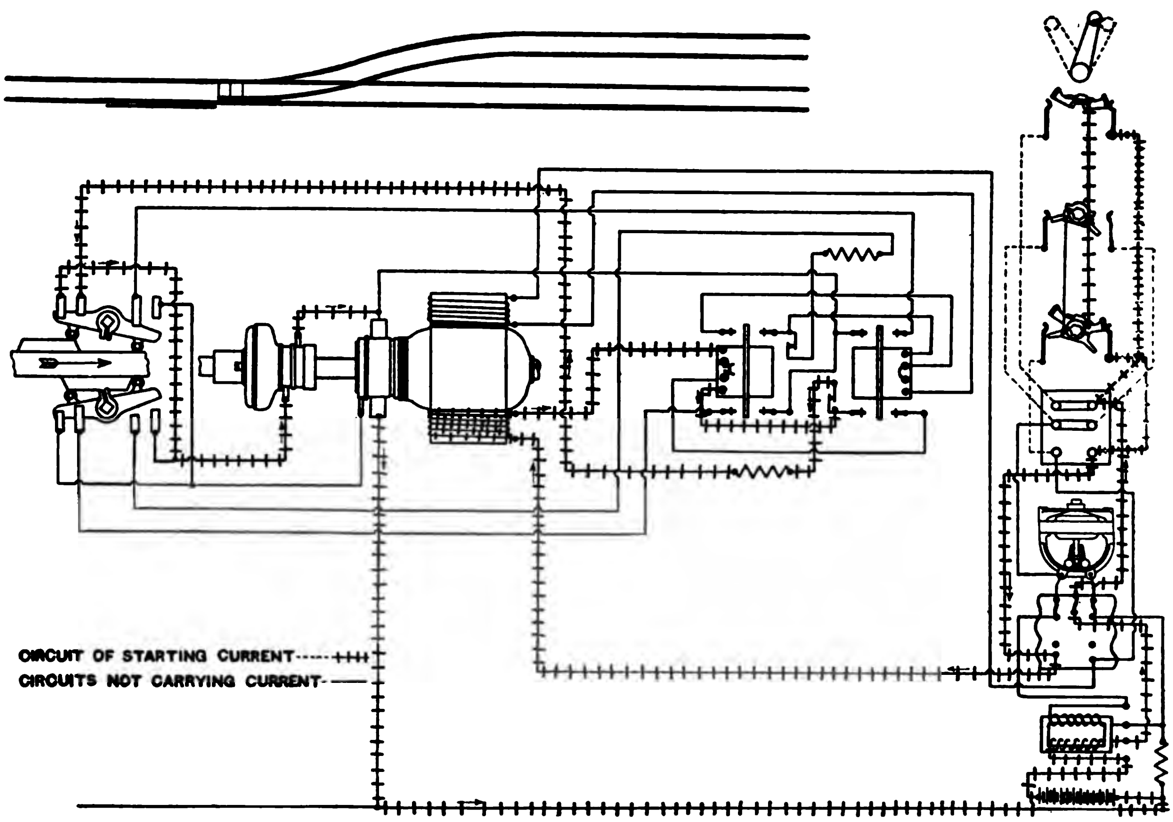


Fig. 1863. Circuits for Single Switch; Switch Normal Lever Against Reverse Stop; Starting Circuit for Reverse Movement Energized.

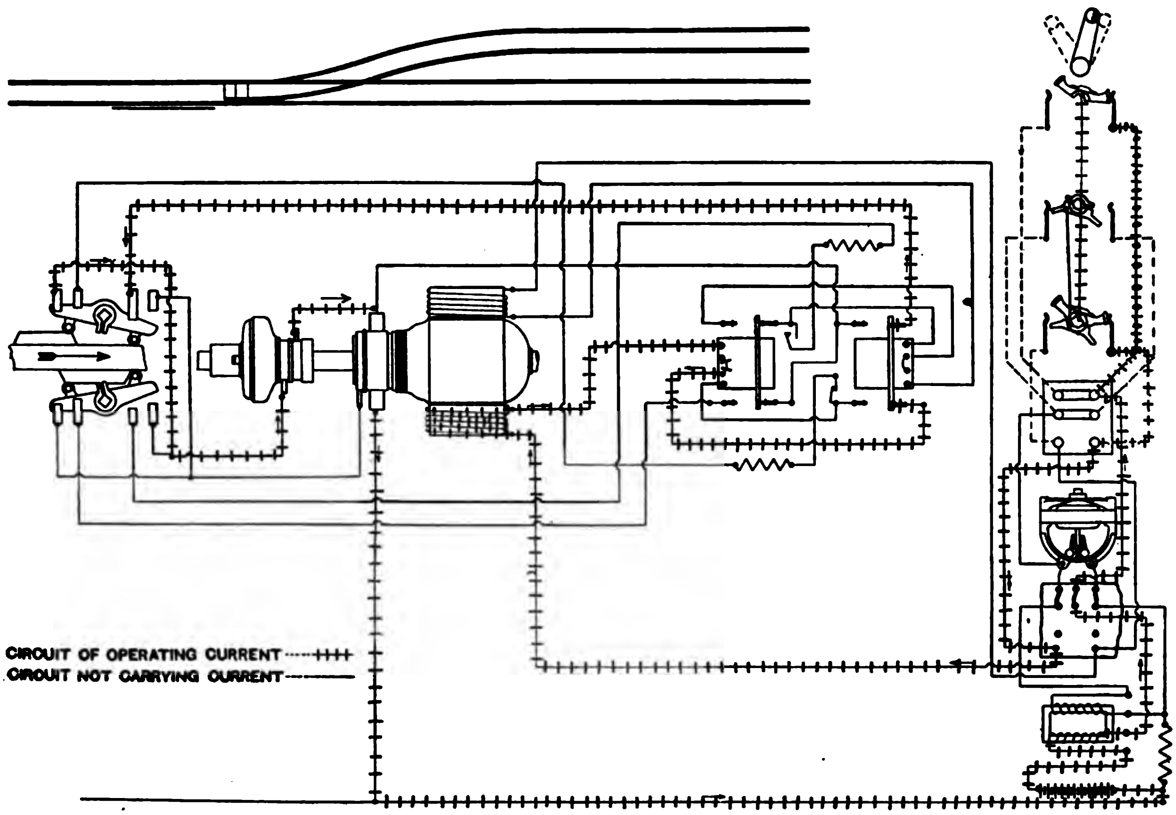


Fig. 1864. Circuits for Single Switch; Lever Against Reverse Stop. Right-Hand Contact Bridge of Circuit Controller Has Moved Against the Back Contacts; Switch Beginning to Move from Normal to Reverse.

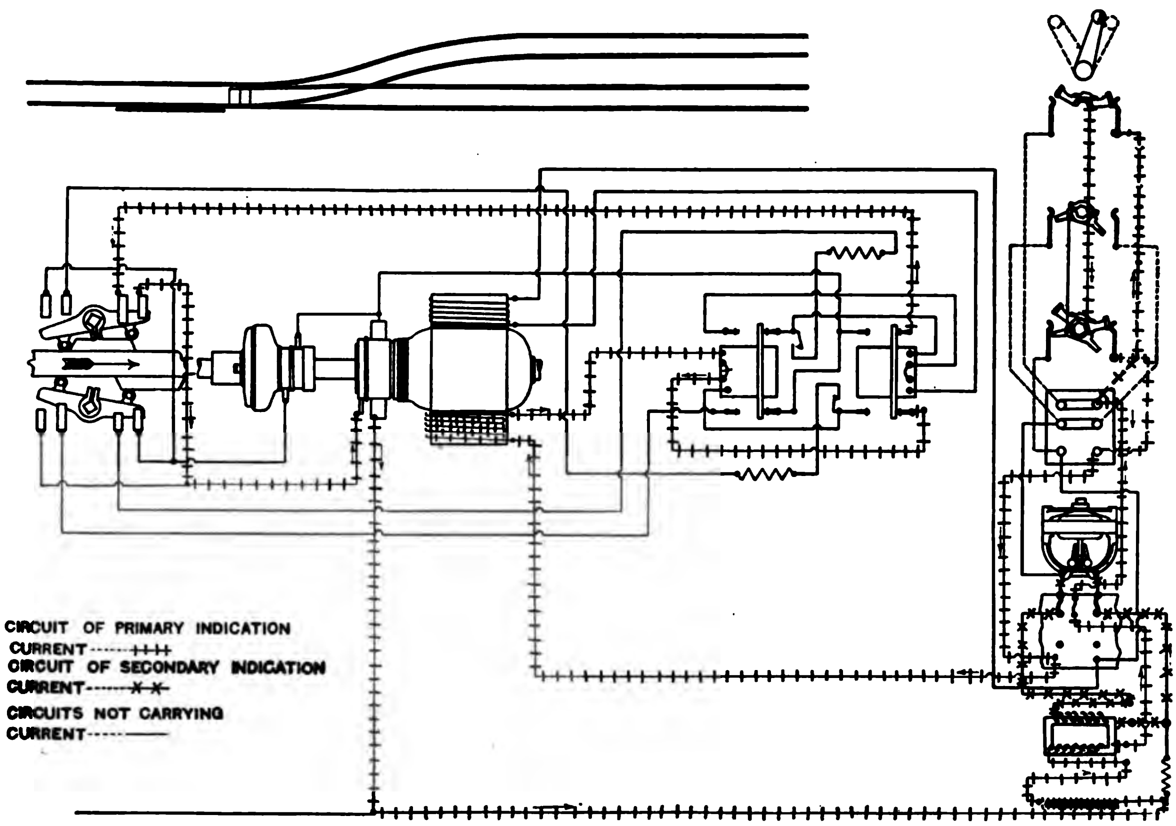


Fig. 1865. Circuits for Single Switch; Lever Against Reverse Stop; Switch Reversed. Knife Switch Actuated by Mechanism Has Opened Operating Circuit and Closed Indication Circuit.

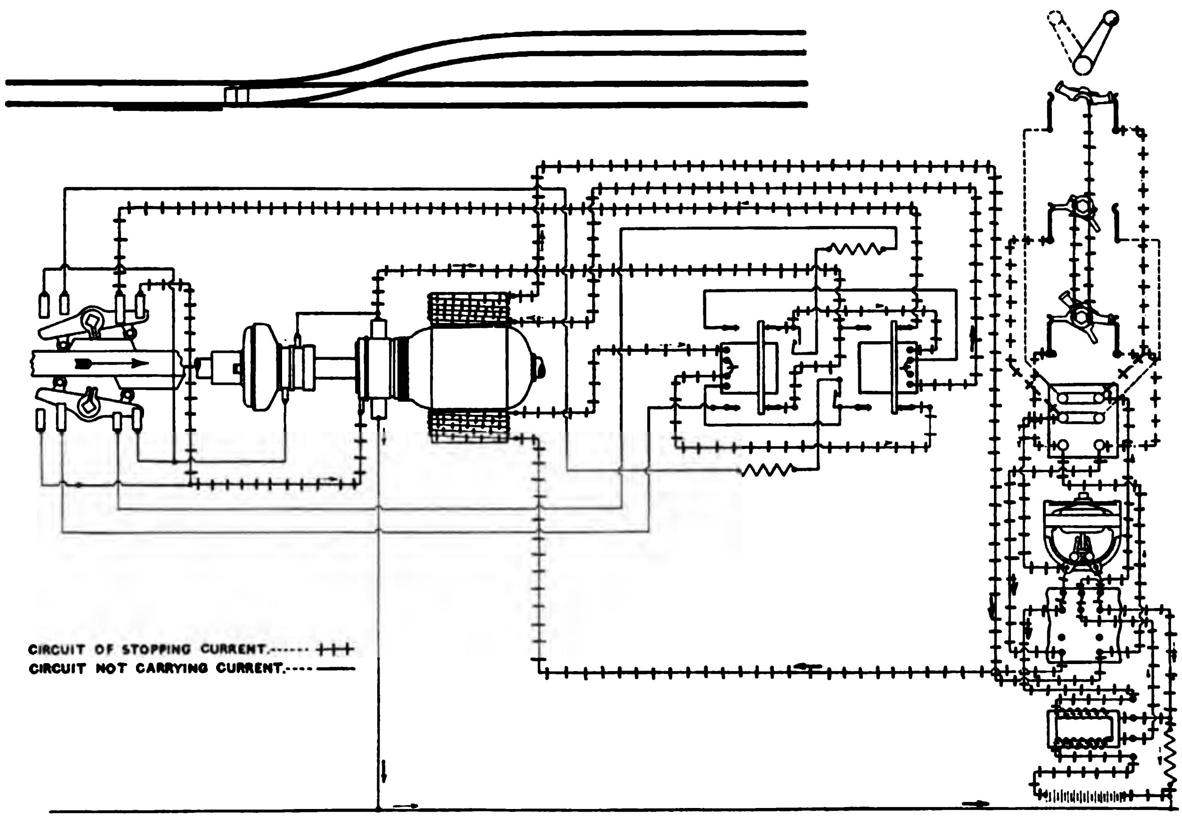


Fig. 1866. Circuits for Single Switch; Lever and Switch Reversed; Stopping Circuit Closed by Final Movement of Lever.

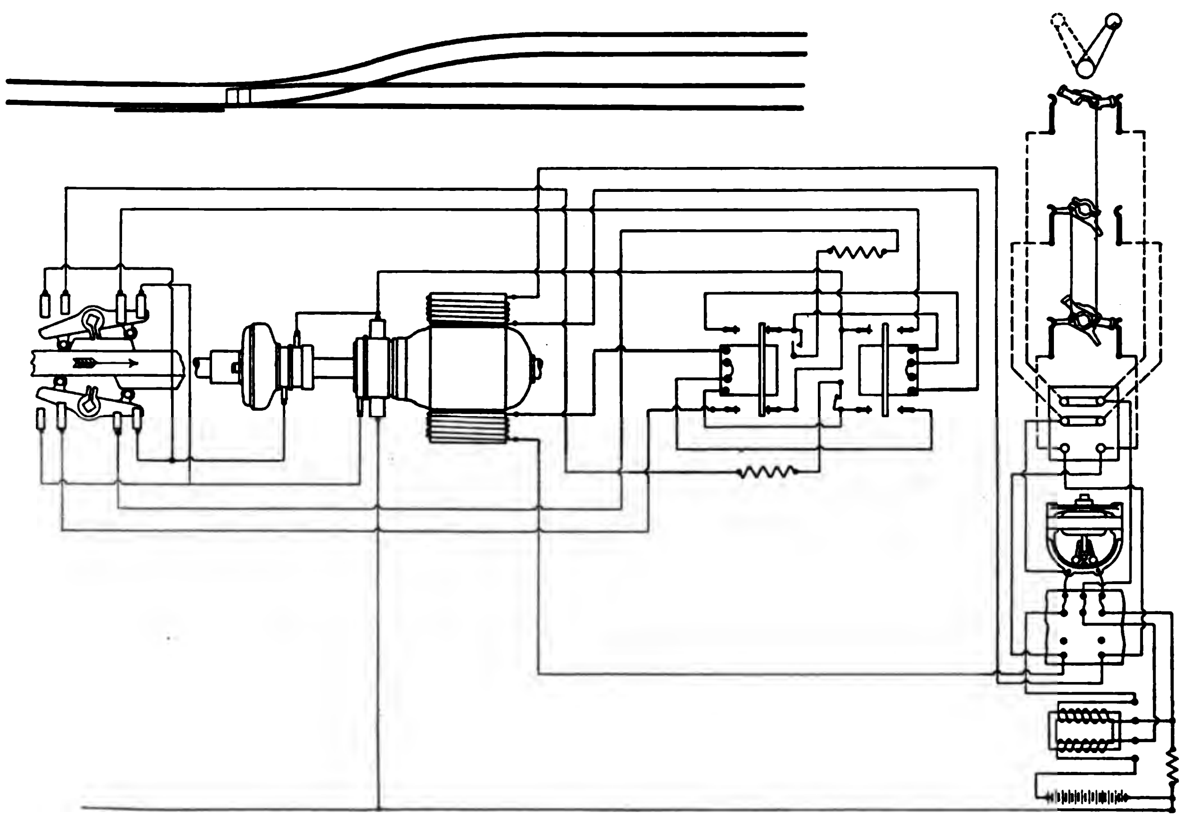


Fig. 1867. Circuits for Single Switch; Lever and Switch Reversed; Stopping Current Has Opened Battery Circuit by Moving Right Contact Bridge of Circuit Controller to Center.

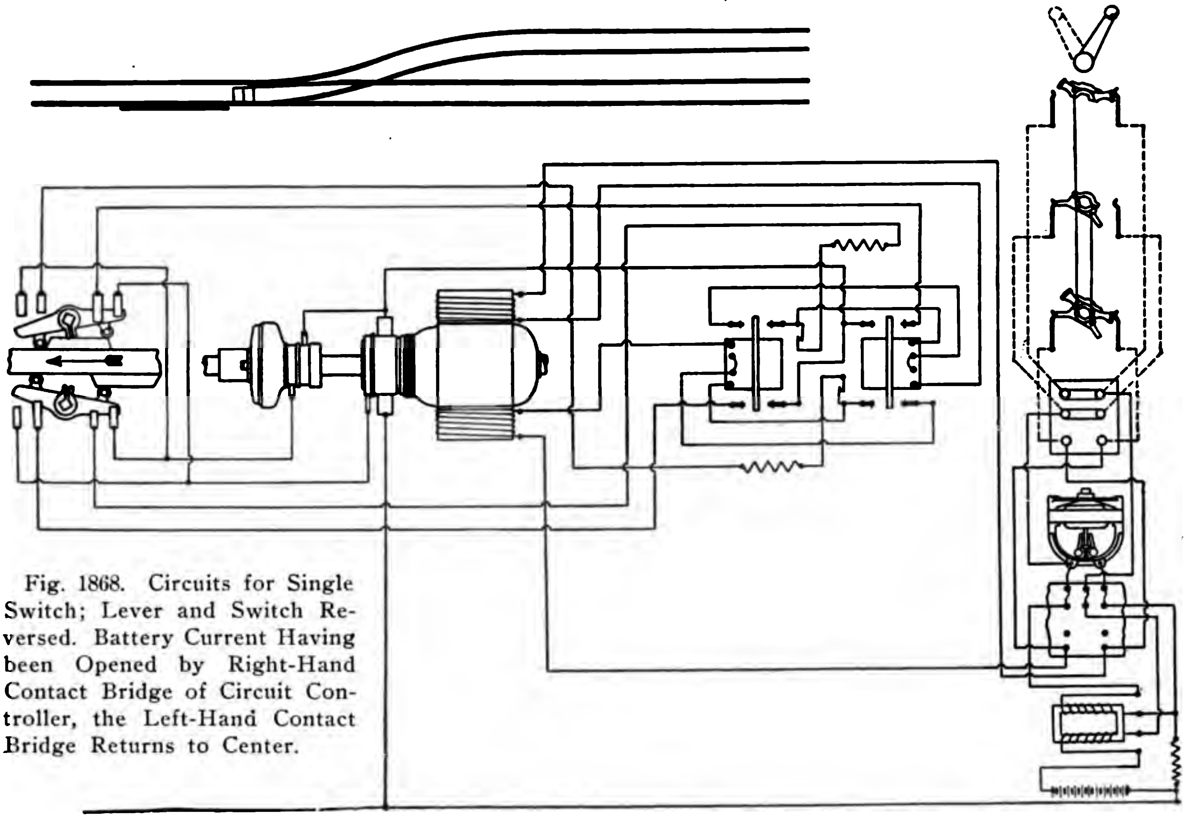


Fig. 1868. Circuits for Single Switch; Lever and Switch Reversed. Battery Current Having been Opened by Right-Hand Contact Bridge of Circuit Controller, the Left-Hand Contact Bridge Returns to Center.

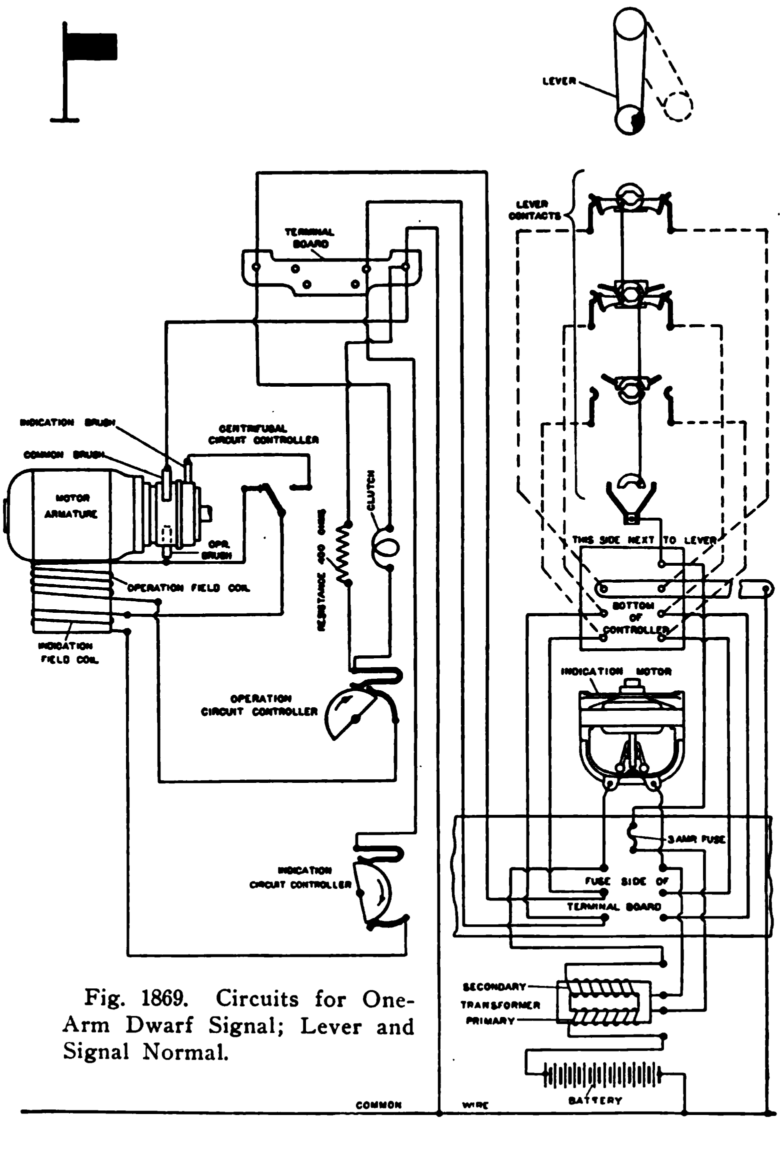


Fig. 1869. Circuits for One-Arm Dwarf Signal; Lever and Signal Normal.

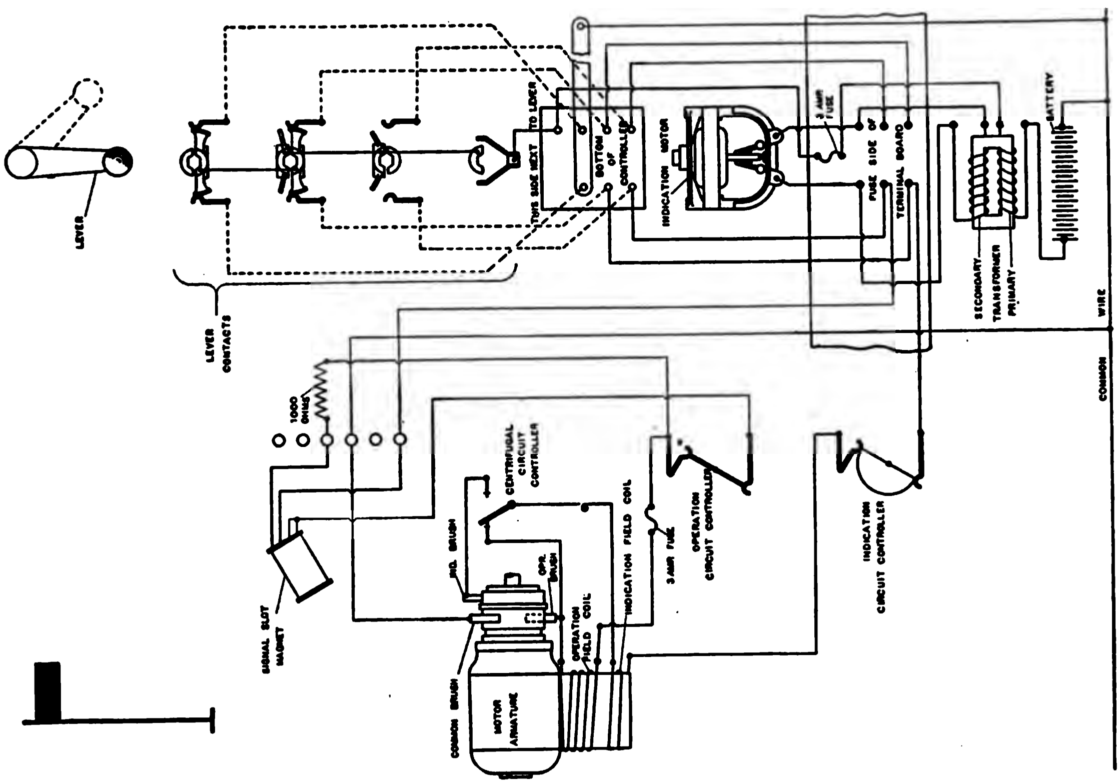


Fig. 1870. Circuits for One-Arm High Signal; Lever and Signal Normal.

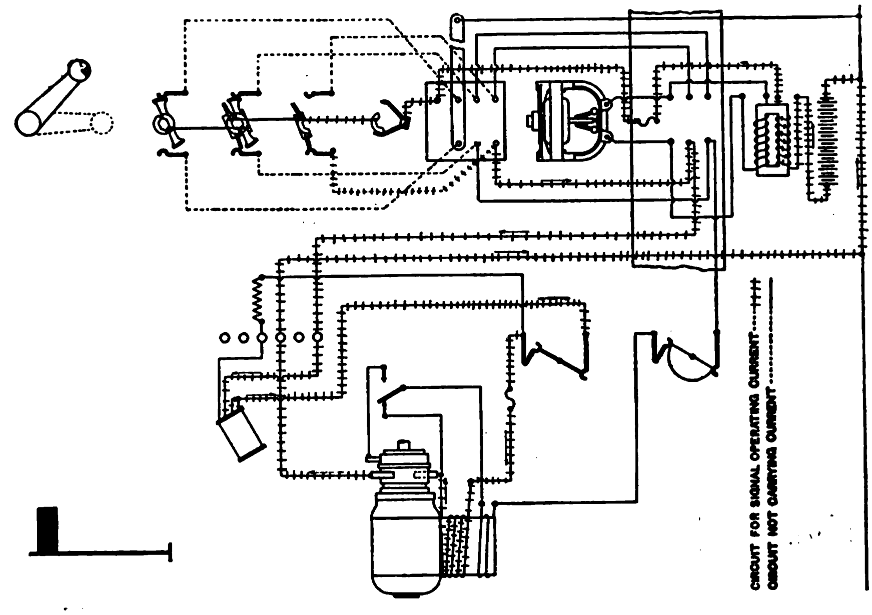


Fig. 1871. Circuits for One-Arm High Signal; Lever Reversed; Signal Normal; Circuit Closed for Clearing Signal.

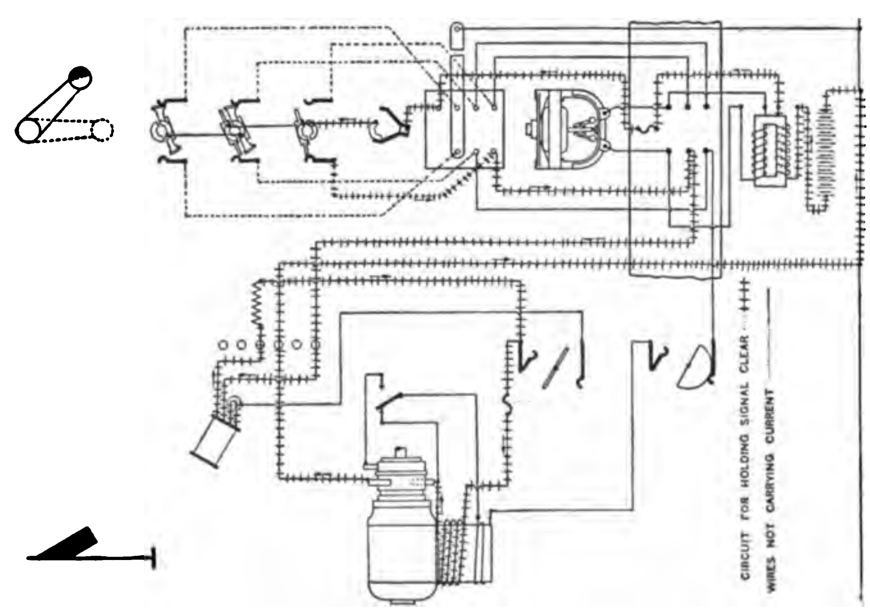


Fig. 1872. Circuits for One-Arm High Signal; Lever Reversed; Signal Clear; Circuit Energized for Holding Signal Clear.

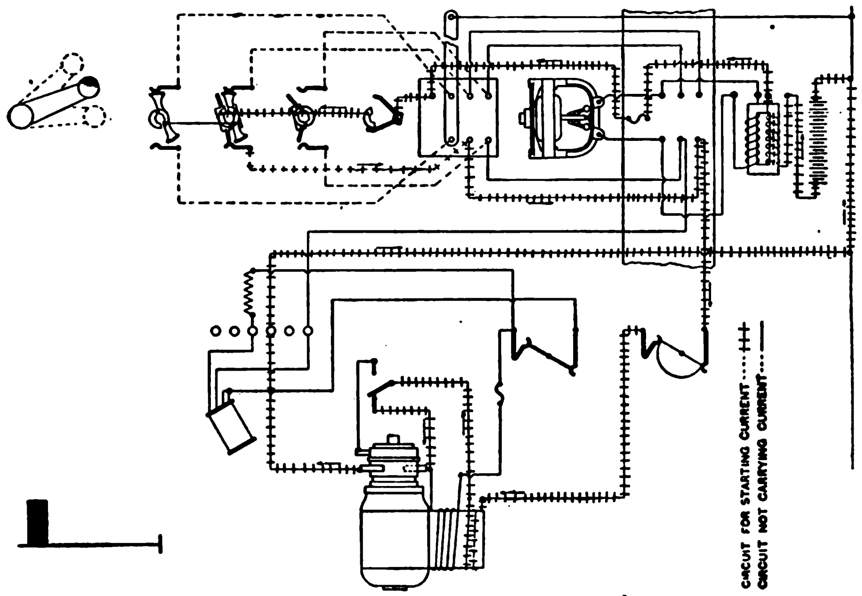


Fig. 1872a. Circuits for One-Arm High Signal; Lever Against Stop; Signal Normal; Circuit for Starting Motor Before Indication Circuit is Closed.

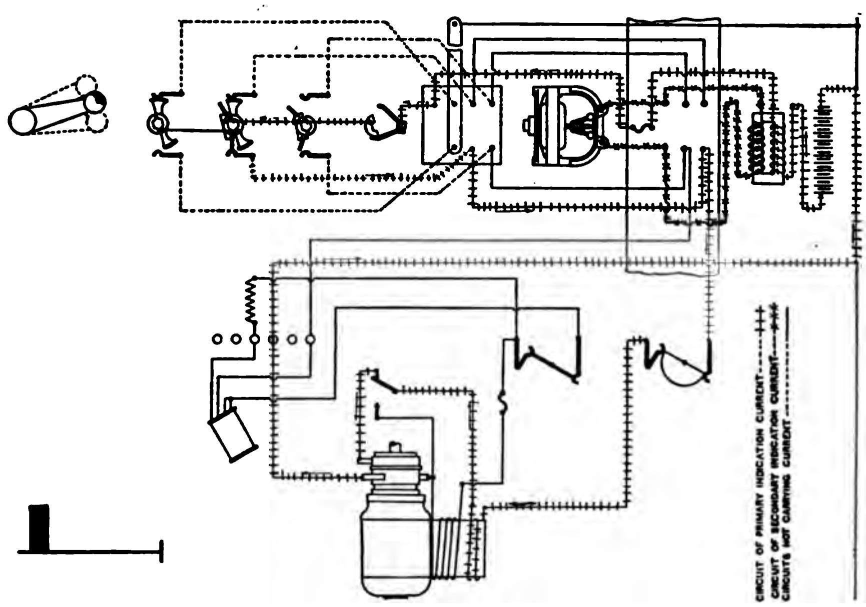


Fig. 1873. Circuits for One-Arm High Signal; Lever Against Stop; Indication Circuit Close by Centrifugal Circuit Controller.

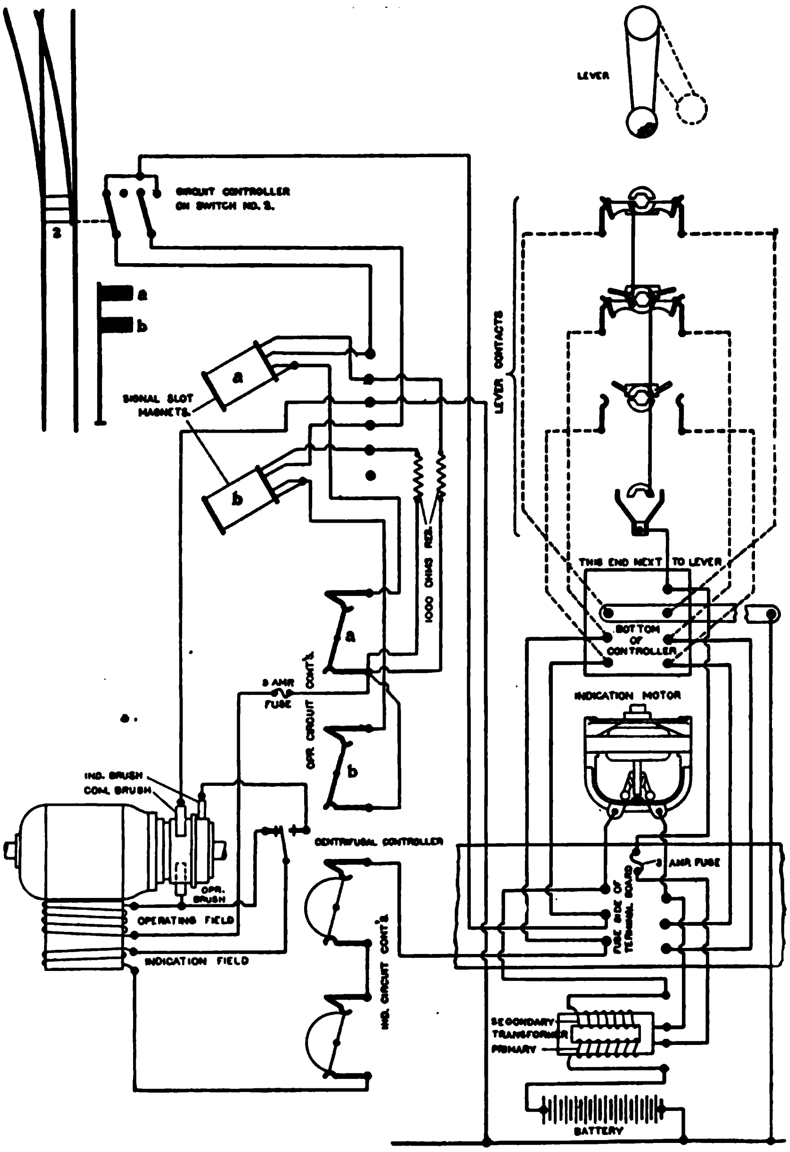


Fig. 1874. Circuits for Two-Arm High Signal; Lever Signal and Switch in Normal Position.

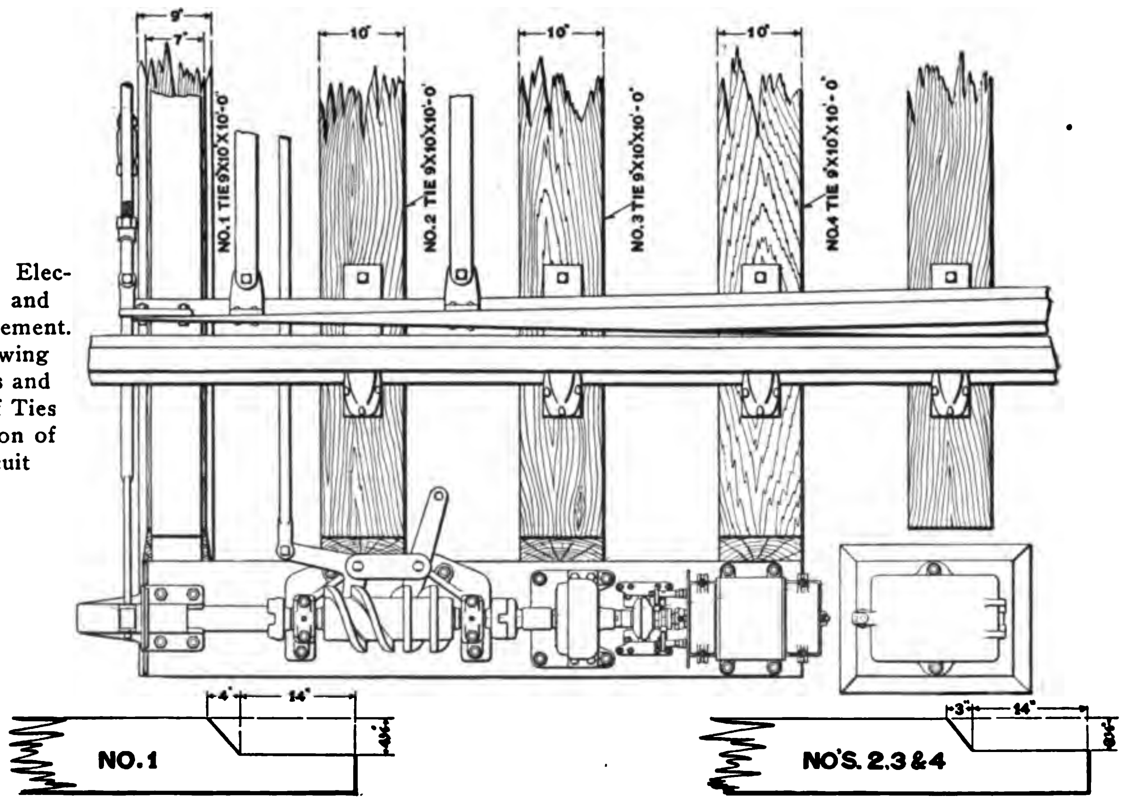


Fig. 1875. Electric Switch and Lock Movement. Views Showing Dimensions and Framing of Ties and Location of Safety Circuit Controller.

Numbers Refer to List of Names of Parts on Following Page.

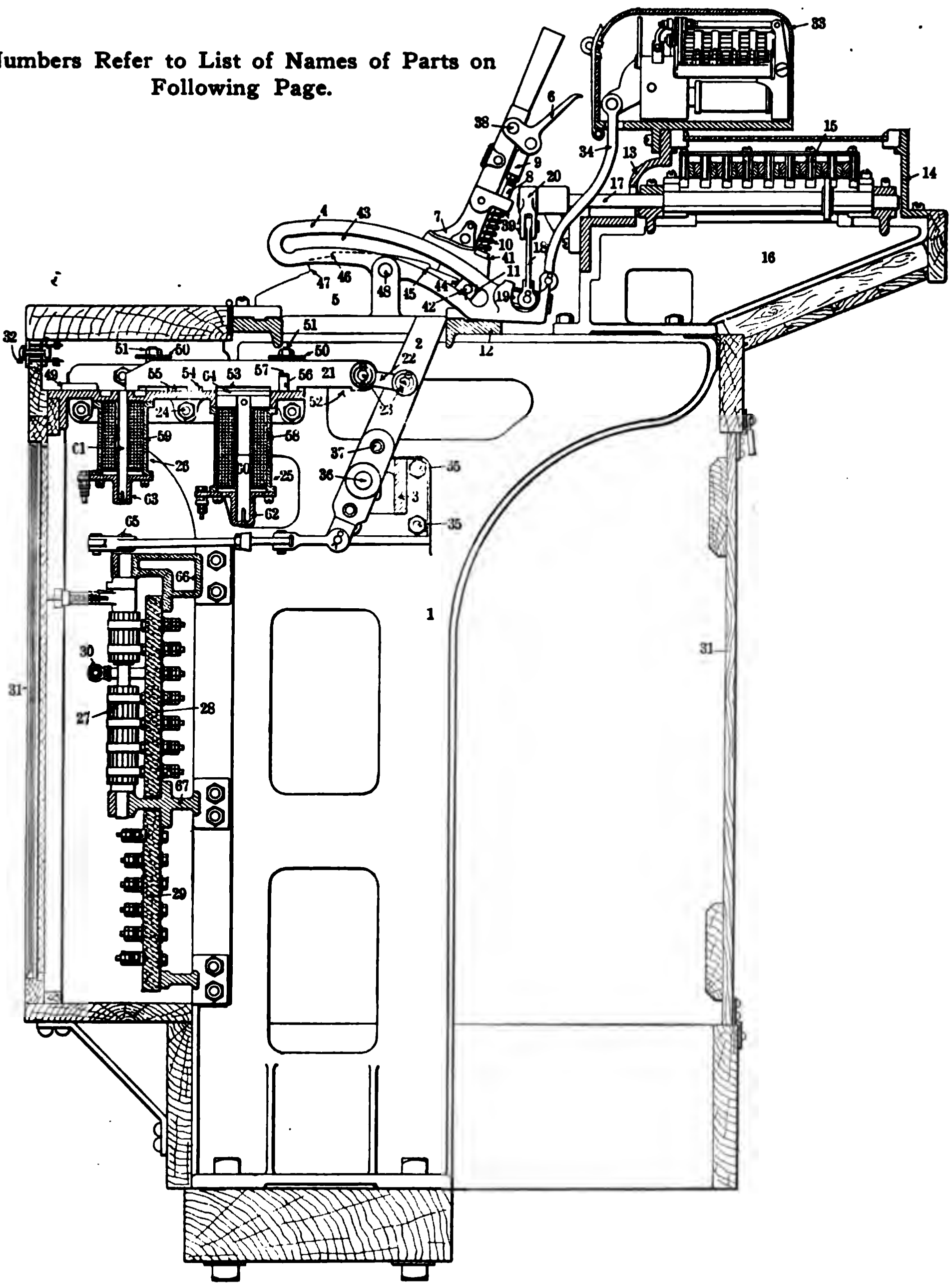


Fig. 1876. End Elevation and Part Section of Federal Electric Interlocking Machine.

ELECTRIC INTERLOCKING.

THE FEDERAL SIGNAL COMPANY.

The machine (Figs. 1876-1877) is a miniature Saxby & Farmer mechanical interlocking machine equipped with circuit controlling and indicating devices to adapt it to use in electric interlocking. The following parts are identical in design, with the corresponding parts of the Saxby & Farmer mechanical machine shown in Figs. 661-667: Machine Leg 1, Lever 2, Bottom Girder 3, Rocker 4, Quadrant 5, Latch Handle 6, Latch Shoe 7, Latch Rod 8, Latch Rod Thimble 9, Latch Rod Spring 10, Rocker Die 11, Top Plate 12, Front Rail 13, Back Rail 14, Locking Bracket 15, Bearing for front and back rails 16, Rocker Shaft 17, Universal Link 18, Pin 19, Rocker Shaft Crank 20, and several other minor parts referred to later.

The following parts are peculiar to this machine and are employed for controlling the various electrical circuits used in the system: Of these devices, 21 is a Lock Slide connected with the lever 2, by means of links 22, and pins 23, Magnet Girder 24, Indication and Locking Magnet 25, Safety Lock 26, Controller 27, mounted on Slate Board 28, Terminal Board 29, Fuse 30, Casing of Machine 31, Push Circuit Controller 32, Electric Lock 33, connecting rod 34, connecting electric lock 33 with rocker 4, besides other essential parts which will be properly described later. The quadrant 5 is machined on its top surface which is curved and formed in steps, two ahead of and two behind a center line passing from pivot 36 through the quadrant, the radii of the curved surfaces are from the same point 36; these steps form notches the use of which will be presently explained. The connecting rod 34, is moved by the rocker 4, and actuates a controlling commutator contained in and controlled by electric lock 33.

On lever 2, at a point below the top plate 12, is attached the lock slide 21. This slide is arranged to slide on the magnet girder 24, between lugs 49, which form guides keeping the slide in place (a portion only of the lug being shown). Plates 50, supported on studs 51, are located above the slides and are used to keep the slide from lifting. The bottom surface of slide 21 is notched or cut out at points 52, 53, 54 and 55. There is a drop latch or dog 56, in the slide 21. This dog is forced down by a spring 57, which presses on its upper end. Mounted on the under side of the magnet girder 24, is the indication magnet 25, and the safety lock magnet 26. Both of these are of the solenoid type encased in iron shells 58 and 59, respectively, wire coils to receive the plungers 60 and 61, are placed within the iron casings. These plungers whose upper ends are of brass project below their respective casings into brass retaining heads 62 and 63. The indication magnet plunger 60, is fitted with a T head of similar length to notches 52 and 53, in the lock slide. This T head occupies a slotted pocket 64, and is made to engage with notches 52 and 53, as occasion requires. The T head normally rests below the top surface of the magnet girder a distance about equal to the depth of notches 52 and 53. The drop latch or dog 56, when the slide is moved forward, will spring downward until it rests on the top of T head of plunger 60. After this dog has so dropped the lever cannot

Names of Parts of Federal Electric Interlocking Machine. Figs. 1876-1877.

1 *Machine Leg*
2 *Lever*
3 *Bottom Girder*
4 *Rocker*
5 *Quadrant*
6 *Latch Handle*
7 *Latch Shoe*
8 *Latch Rod*
9 *Latch Rod Thimble*
10 *Latch Rod Spring*
11 *Rocker Die*
12 *Top Plate*
13 *Front Rail*
14 *Back Rail*
15 *Locking Bracket*
16 *Front and Back Rail Bearing*
17 *Rocker Shaft*
18 *Universal Link*
19 *Pin for Universal Link*
20 *Rocker Shaft Crank*
21 *Lock Slide*
22 *Locking Slide Link*
23 *Turned Pin*
24 *Magnet Girder*
25 *Indication and Locking Solenoid*
26 *Safety Lock Solenoid*
27 *Circuit Controller*
28 *Slate Board*
29 *Terminal Board*
30 *Fuse*
31 *Machine Casing*
32 *Push Circuit Controller*
33 *Electric Lock*
34 *Connecting Rod*
35 *Frame Bolt*
36 *Pivot Pin*
37 *Tap Bolt*
38 *Latch Handle Pivot Pin*
39 *Rocker Shaft Crank Pin*
41 *Washer*
42 *Pivot for Rocker Die*
43 *Slot in Rocker*
44 *Normal Notch in Quadrant* **5**
45 *Normal Indication Notch in Quadrant* **5**
46 *Reverse Indication Notch in Quadrant* **5**
47 *Reverse Notch in Quadrant* **5**
48 *Rocker Pivot Pin*
49 *Lug for Guiding Lock Slide* **21**
50 *Plate for Guiding Lock Slide* **21**
51 *Stud for Supporting Plate* **50**
52 *Reverse Notch in* **21**
53 *Normal Notch in* **21**
54 *Reverse Safety Notch in* **21**
55 *Intermediate Safety Notch in* **21**
56 *Indication Drop Latch or Dog*
57 *Spring for* **56**
58 *Iron Solenoid Shell for* **25**
59 *Iron Solenoid Shell for* **26**
60 *Indication Solenoid Plunger*
61 *Safety Solenoid Plunger*
62 *Retaining Head for* **60**
63 *Retaining Head for* **61**
64 *Slotted Pocket for Head of* **60**
65 *Spindle*
66 *Top Commutator Girder*
67 *Bottom Commutator Girder*
68 *Switch Blade for Operating Circuit*
69 *Switch Blade for Indication Circuit*
90 *Positive Bus Bar*
91 *Negative Bus Bar*
92 *Binding Post*
93 *Binding Post*
94 *Binding Post*
95 *Binding Post*
96 *Binding Post*
97 *Binding Post*
98 *Fuse Terminal*
99 *Fuse Terminal*

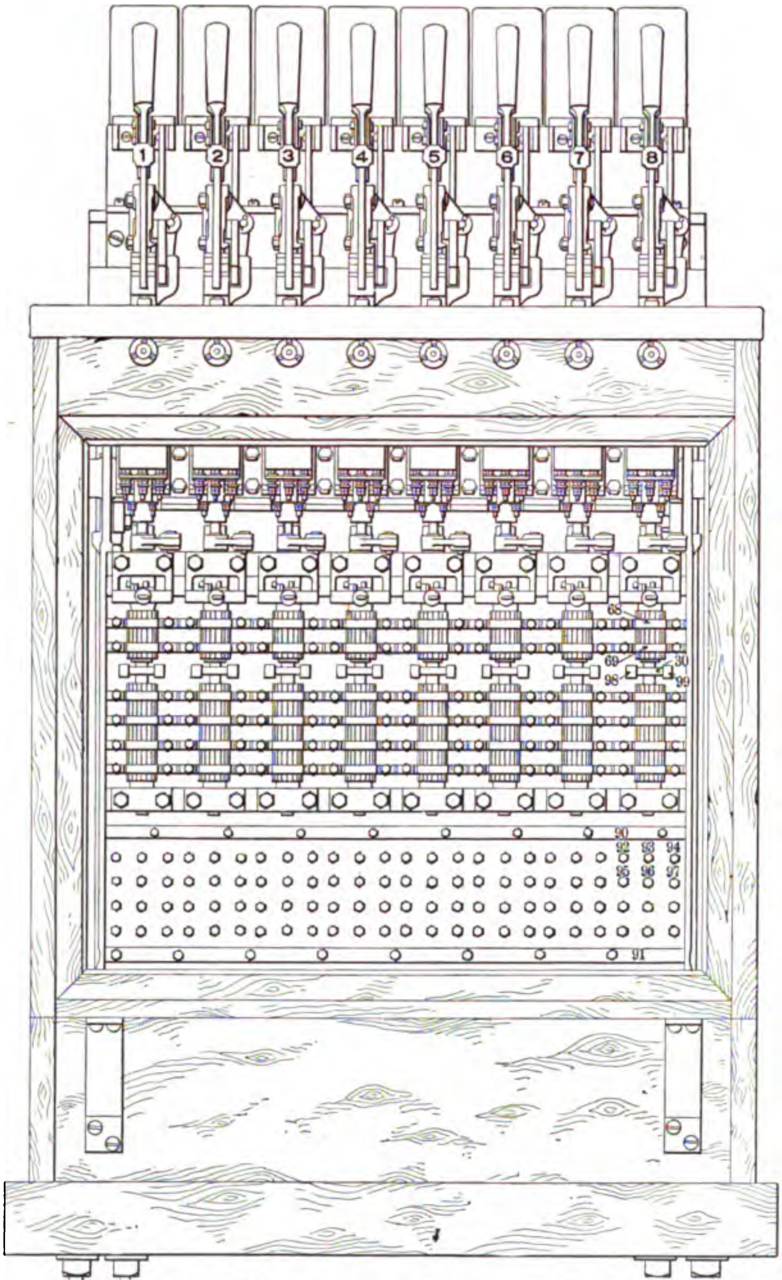
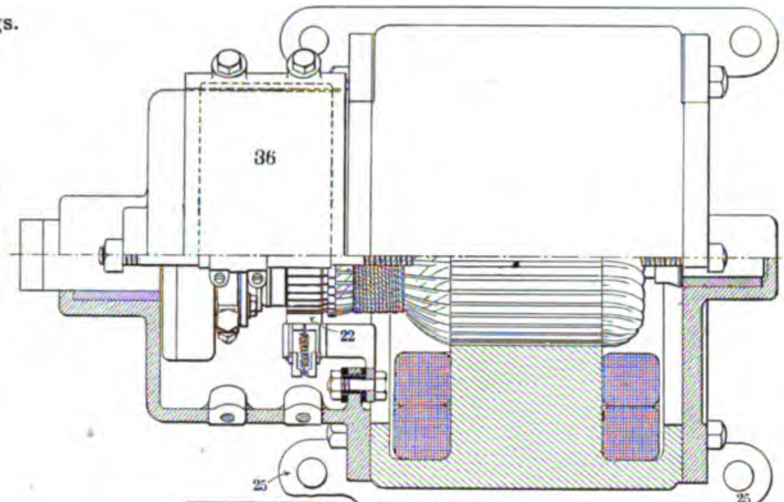


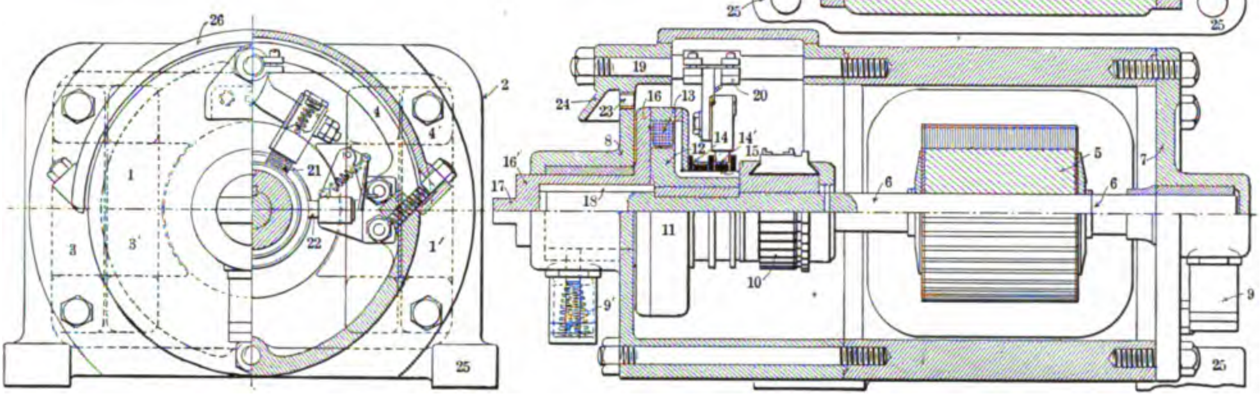
Fig. 1877. Front View Federal Electric Interlocking Machine.

be either replaced or moved any further forward than the length of the slotted pocket 64, as the dog is confined in the pocket and is raised only by the plunger 60, as will be shown. The plunger 61, of safety lock 26, is designed to lift sufficiently to enter notches 54 and 55, and also to rise beyond the extreme end of the slide 21. Considering now that all circuits are normal and that the lever 2, occupies its normal position, there is no current flowing through either the indication or safety magnets. If, however, current should reach either of these magnets at this time, their respective plungers would be raised and enter the notches in the lock slide 21, thus preventing any movement of the lever. The same condition would exist if the lever were completely reversed. In this case the notch 52, in the lock slide 21, would be in the position now occupied by notch 53, that is directly over the pocket 64, of the indication magnet 25, the notch 54, would be directly over the plunger 61, of lock magnet 26. It will be readily seen that if current should reach either of these magnets with the lever 2. in the reverse position that the lever would be locked and could not be returned to its normal position until current was cut off from these magnets. Thus the lever is immovable if a cross or ground of dangerous character exists in any of the circuits. The lever actuates controller 27, which may be described as follows: A spindle 65, is mounted in bearings on the top and bottom commutator girders 66 and 67. Attached to the spindle 65, and operated thereby are switch blades 68 (Fig. 1877) for the operating circuit and 69, for the indication circuit. These switch blades are mounted loosely on the spindle 65, and insulated therefrom by means of rubber or fibre bushings which are formed outside of metal tubes turning freely on the spindle. The switch blades are provided with extension collars which engage contact

Names of Parts, Federal Switch Motor; Figs. 1878-1880.

1	*Pole*	14	*Collector Ring*
2	*Frame*	15	*Insulating Ring*
3	*Field Coil*	16	*Clutch Armature*
4	*Field Coil*	17	*Tongue End of Hub*
5	*Armature*	18	*Bushing*
6	*Shaft*	19	*Bolt*
7	*Motor Head*	20	*Brush Holder*
8	*Motor Head*	21	*Brush*
9	*Oiler*	22	*Collector Ring Brush*
10	*Oiler*	23	*Insulated Wire Inlet*
11	*Magnetic Clutch*	24	*Protecting Shield*
12	*Clutch Frame*	25	*Lug*
13	*Clutch Coil*	26	*Cover*

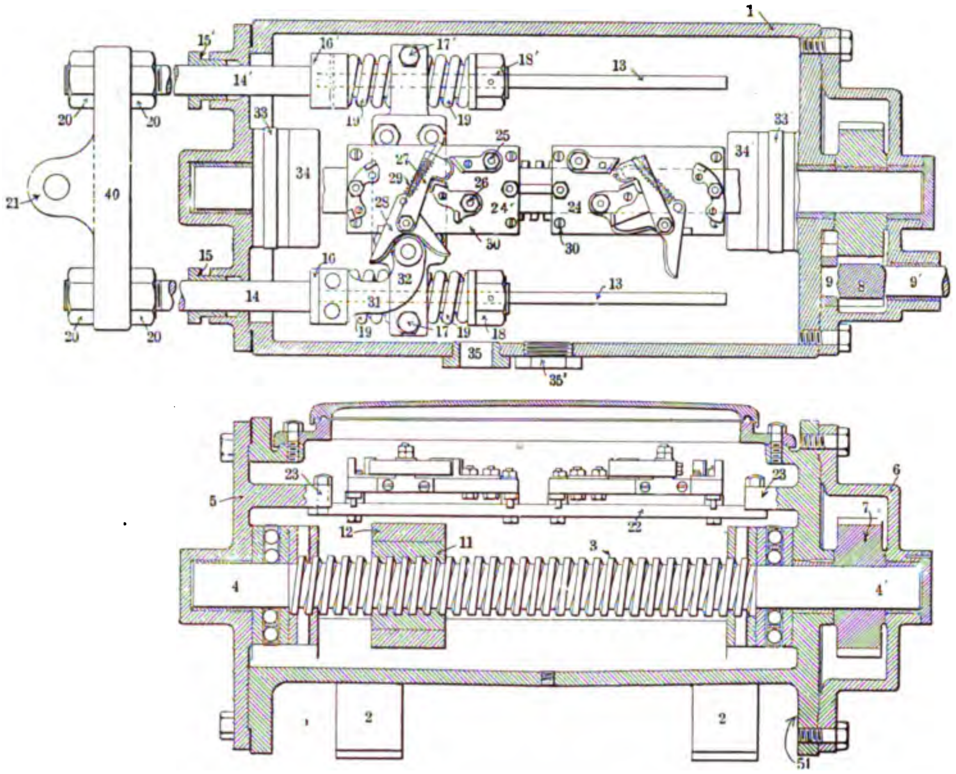




Figs. 1878-1880. Switch Motor.

fingers attached to 28. There are also mounted loosely on the spindles 65, toggled driving members which are arranged to engage with the switch blade bushings at a certain part of their movement and throw or force the blades into their respective contacts. Two contacts for each switch blade are located one on each side of the spindle 65. An operating rod and crank are provided to connect the lower end of the lever 2, with the spindle 65, and transmit motion from the lever to the spindle. The toggle devices are directly moved by driving collars rigidly fixed to the spindle 65. In addition to the apparatus just described, the spindle 65 carries an insulating bushing on which are mounted contact rings which engage with contact fingers. These rings and fingers make and break the safety circuit.

The terminal board 29, serves as means for connecting the different conductors from the controller 27, to the wires leading out from the machine. On this board are mounted the positive and negative bus bars 90 and 91 (Fig. 1877), which run the entire length of the machine, and six binding posts 92, 93, 94, 95, 96, 97, also the fuse terminals 98, 99. Suppose the source of electrical energy to be properly connected across the bus bars, current passes from the positive bus through a conductor to the fuse 30, thence to one terminal of a low resistance winding of about .5 ohms in the safety magnet 26, through the contacts of the operating switch 68. From this the current may go to either the normal of the reverse operating circuits which control the movement of the switch operating mechanism in either the normal or the reverse direction. From the fuse the circuit also runs to one terminal of the winding of indication magnet 25, thence to the indication switch blade through contact 69, thence in the same manner as the control circuit to the normal or reverse indication circuits. Another circuit from the positive bus is through a high resistance winding of the safety magnet 26. After passing through this winding, the circuit joins that of the low resistance winding, which connects with the switch 68. The operation of a lever for a switch or derail is as follows: The first movement of lever 2, moves the lock slide 21 forward until the dog 56 drops into pocket 64. This movement also brings notch 55 over plunger 61 of safety magnet 26. At the same time that the dog 56 drops, the controller 27 will have turned sufficiently to open the contact between the ring and fingers, thus breaking the safety circuit at this point. If the slide is advanced still further until the lever latch drops behind the notch 46, the toggle switch 68, will snap over making up the reverse operating circuit which will operate the switch to which it is connected. Current will now flow through the windings of the magnet 26, and the plunger 61 will project into the notch 55, in the lock slide 21, the plunger will remain up until the magnet becomes de-energized by the breaking of the operating circuit at the switch. So long as the plunger 61 is up the lever 2 cannot be placed in the complete reverse position nor returned to its normal position, therefore if the current supplied to the circuit should become grounded (and take current of sufficient strength to blow the fuse 30) the plunger 61, would still stay up owing to the magnet 26 being energized by the current in the high winding which, as before explained, is connected to the positive bus, but not through the fuse 30. This high winding will not permit sufficient current to flow in the circuit to operate the switch, therefore no movement of the switch apparatus will take place. The fault causing the ground must however be removed before the plunger 61 will allow any further movement of the lever. If, however, the circuit was normal and the switch movement operated correctly the motor would open the circuit at that point, but close the normal circuit which is now open at the controller contacts. This breaking of the circuit will cause the plunger 61 to drop back. After the switch apparatus has opened the operating circuit a device operated by the switch after reaching a predetermined position closes the reverse indication circuit, causing the indication magnet 24 to become energized. This raises its plunger 60, the T headed portion of which now forces up the spring dog 56, out of the pocket 54 where it was acting as a lock against any further movement of the slide 21, or lever 2. When the dog is lifted the lever 2 may be pulled forward to notch 47, at which point the controller 27 will have turned sufficiently to operate the toggle switch and break at that point the indication circuit. It will be seen that if the indication magnet were to become improperly energized while the lever 2 was in either its normal or reverse position the slide 21 would be locked, if, however, the magnet 25 should be improperly energized while current was passing through magnet 26, magnet 26 would lock the slide 21, even though the T headed plunger 60 should release the dog 56. Therefore, unless the switch apparatus is de-energized (which condition can only exist when the switch is either fully normal or reversed) the lever 2 will be locked up by the magnet 26, and, as the indication magnet can only be properly energized after the switch mechanism has made a complete movement the dog 56 will not release the slide 21, until the proper time. Therefore, two entirely opposite conditions must obtain simultaneously in order to permit an improper movement of the lever, viz., an improper de-energization of the magnet 26, and an improper energization of magnet 25. After the lever has reached notch 47, the



Figs. 1881-1882. Switch Reducing Gear.

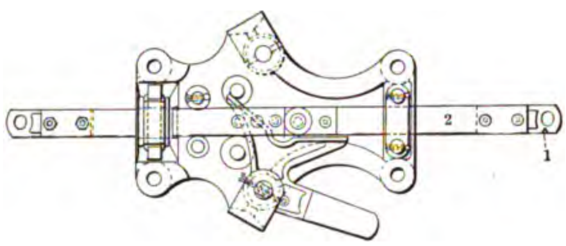


Fig. 1883. Switch and Lock Movement.

Names of Parts of Federal Switch Gear; Figs. 1881-1882.

1	*Casing*	20	*Nut*
2	*Lug*	21	*Crosshead Lug*
3	*Worm*	22	*Supporting Bar*
4	*Bearing*	23	*Lug on Casing*
5	*Casing Head*	24	*Cut Out Switch*
6	*Housing*	25	*Binding Post*
7	*Driving Gear*	26	*Binding Post*
8	*Pinion*	27	*Switch Arm*
9	*Bearing*	28	*Escapement Crank*
11	*Nut*	29	*Taggle Spring and Pin*
12	*Yoke*	30	*Insulating Base*
13	*Way for* **12**	31	*Switch Operating Arm*
14	*Operating Rod*	32	*Insulated Roller*
15	*Stuffing Box*	33	*Thrust Bearing*
16	*Collar*	34	*Collar*
17	*Lug on* **12**	35	*Wire Inlet*
18	*Nut*	40	*Crosshead*
19	*Helical Spring*		

safety circuit at ring and finger on 27 is made up. This closes a path from the closed contact at the switch apparatus to the negative bus bar. The function of this current is to provide a circuit of practically no resistance in shunt with the switch movement to common, so that if positive current should reach the switch movement improperly this stray current would not tend to operate the switch but on the contrary take the short cut to negative which would result in opening the main circuit either at a fuse or at the main overload circuit breaker.

What has been said of the operation of the lever 2, in the forward direction describes its operation in the reverse direction except that the reverse circuits are made and broken. The magnets 25 and 26 are energized the same as before.

The full movement of lever 2, of course, causes the rocker 4 to oscillate which in turn transmits motion to the rock shaft 17, thus operating the mechanical locking in the same manner as in a mechanical machine.

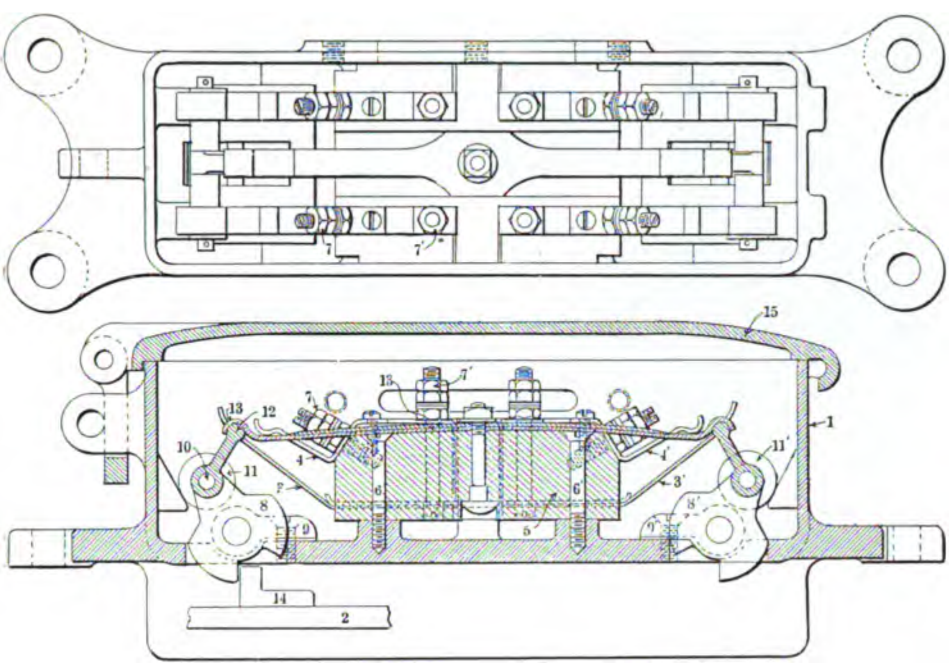
The electric lock 33 also controls the lever 2, by locking or releasing a rocking dog attached to connecting rod 34. The function of this dog is to prevent or permit movement of the rocker 4, inasmuch as the latch rod 8 cannot be lifted unless the rocker 4 is free. This electric lock 33 is an important part of this machine when electric locking is employed.

The switch motor (Figs. 1878-1880) is designed to operate at an E.M.F. of 75 to 125 volts, and is of the bipolar type. The poles 1, 1', are arranged horizontally in the frame 2. Four field coils 3, 3', 4, 4', are mounted on the pole pieces 1, and 1'. An armature 5 is mounted between the poles with its shaft 6 journaled in the motor heads 7 and 8. Oiling devices 9 and 9', are attached to the heads 7 and 8.

On the shaft is mounted the commutator 10, also the magnetic clutch 11. This clutch 11 forms a flexible connection between the motor and the gear mechanism. This clutch is of the angular type and is constructed with an angular groove into which an angular coil of wire 13 is secured. Collector rings 14 and 14' are mounted on and properly insulated from the hub of the clutch 11, by the insulating sleeves and rings 15, and a key secures the clutch 11 to the shaft 6, so that it will turn with it.

An armature 16, is mounted on the shaft 6. This armature 16 is constructed with a long hub 16', which is formed with a tongued end 17, designed to engage with a grooved member attached to the gear mechanism. The hub 16', of the clutch 16, is hollow and bushed with material that does not require oiling. This bushing 18 is so placed that it cannot be conveniently oiled, otherwise, oil coming in contact with the faces of the clutch and armature might cause the clutch to slip. The armature shaft 6 is journaled in the bushing 18.

A stud 19 is arranged in the motor head 8 to secure the head to the frame of the motor and to support the brush holder 20, which in turn supports two brushes 21 and 21' (only one being shown) which are in contact with the collector rings 14 and 14'. The ends of the clutch coil 13 are connected to the collector rings 14 and 14', respectively. One pair of the field coils 4, are arranged to operate the motor in one direction, and the other pair 4', in the other direction. Each pair of field coils is connected in series with the armature and the magnetic clutch, although only one pair is energized at a time. To accomplish this three wires are connected to the motor as follows: One wire, called the normal operating wire, runs from the interlocking machine to one set of field coils, through them in one direction, thence through the armature, the magnetic clutch coil, to a common return wire, back to the interlocking machine. A second wire, called the reverse



Figs. 1884-1885. Indication Box.

Names of Parts of Federal Indication Box. Figs. 1884-1885.

1 *Box*
2 *Slide Bar of Switch and Lock Movement*
3 *Lower Contact Spring*
4 *Upper Contact Spring*
5 *Insulating Spring Base*
6 *Screw*
7 *Binding Post*
8 *Toggle Tumbler*
9 *Bearing for 8*
10 *Toggle Pin*
11 *Insulating Roller*
12 *Link*
13 *Tension Spring*
14 *Operating Lug on 2*
15 *Cover*

Fig. 1886. Signal Mechanism in Place.

operating wire, runs from the controlling machine to the other pair of field coils in a direction opposite to the flow through the first mentioned pair, thence to the same point leading into the armature, and as before described to the common wire back to the interlocking machine. It is obvious that by energizing either of these operating wires that the armature will rotate in one direction or the other according to which field is used.

Brush holders and brushes 22, are mounted on and insulated from the frame 2, of the motor for conveying current into and out of the armature 5. Insulated wire inlets 23 are provided in the end of the motor head 8. There is also a protecting shield 24, situated in the head directly over the wire inlets. Lugs 25 extend out from the base of the motor frame 2, to be used for attaching motor to foundation bed-plate. A cover 26 is arranged over an opening above the clutch rings and commutator and is bolted to the head 8, protecting the interior of the motor from the weather.

The general operation of the motor is as follows: The tongue 17, of armature 16, engages with a grooved shaft on the gear mechanism which is the apparatus to which the motor is connected. This armature 16 is free to turn in its bearing in the motor head 8, and to revolve freely on shaft 6, of the armature 5. Now, if current of proper strength is supplied to one of the operating wires, the field coils connected with that wire will become energized and the armature will rotate, at the same time the clutch coil 13 will become energized (it being in series with the motor) and the clutch 11 will strongly grip the armature 16, causing it to rotate with the clutch 11, thus operating the mechanism to which the armature is connected. As soon as current in the above circuit is cut off, the armature 16 will cease to revolve owing to the

Fig. 1887. Federal Electric Interlocking Machine.

Fig. 1888. Motor Dwarf Signal.

Fig. 1889. Electric Switch and Lock Movement Complete in Place.

de-energizing of the clutch 11, the armature being free to revolve may, owing to its inertia, make a few turns before coming to rest. If current is now supplied to the other circuit of the motor the armature 5 will revolve in an opposite direction and the clutch 11, as before, will grip its armature 16, and operate the mechanism to which it is attached.

Fuse protection is provided in the motor circuits so that if the work to which the motor is applied is beyond the overload capacity of the machine, the circuit will be opened. If the machine be overloaded but not beyond the capacity of the fuses the magnet clutch 11, and its armature 16, will slip thereby protecting the motor or other apparatus from undue strain or derangement which might otherwise occur.

The switch gear mechanism (Figs. 1881-1882) is composed of the cast iron casing 1, from which project lugs or feet 2, which are used to secure the gear to the base plate. A screw 3 is mounted on the casing 1, and revolves in bearings 4 and 4' in the casing heads 5. A housing 6 is bolted to one of the heads, and contains a driving gear 7, which is keyed to the screw shaft 4. This housing 6 also contains a pinion 8, which engages with the gear 7, and operates it. The pinion 8 is constructed with bearings 9 and 9', which are formed in housing 6. The bearing spindle 9', extends outside the housing 6, and has attached to it a grooved coupling which is arranged to connect with a tongue 17 (Fig. 1880) on the driving shaft of the motor. A nut 11 is secured in a steel yoke 12. The worm 3 passes through the nut. The yoke 12 slides on ways 13, in the casing 1. These ways prevent the nut and yoke from turning the screw 3. Operating rods 14 and 14' pass through guides in the head 5, which are provided with stuffing boxes 15 and 15', to insure tight joints at these points. The rods 14 and 14', each have a square collar 16 and 16', formed on that portion of the rod, which extend inside the casing 1. These rods extend through projections or lugs 17 and 17', on the yoke 12. On the extreme end of the rods which pass through the lugs 17 and 17', are threaded the nuts 18 and 18'. Heavy helical springs 19 are interposed on the rods 14 and 14', between the square portion of the rods and the yoke lugs 17 and 17', and also between the nuts 18 and 18', and the opposite side of lugs 17 and 17'. These springs being of uniform and equal flexibility do not affect the mechanism in any way while it remains at rest. The ends of the operating rods which extend outside the casing 1 are joined by a cross head 40, which is clamped firmly in position by means of the nuts 20. This cross head has a lug 21, by which connection is made to the slide bar of a switch and lock movement or other device to be operated.

In the casing 1, above the screw 3, is a bar 22, attached to projecting lugs 23, on the heads 5, of the casing. Mounted on the bar 22, are cut out switches 24 and 24'. These switches are of the toggle type and consist of two contact posts 25 and 26, the switch arm 27, the escapement crank 28, and the toggle spring and pin 29. These parts are mounted on an insulated base 30, which is adjustable on the bar 22. Mounted on the square portion of the rod 14, is a switch operating arm 31. This arm carries an insulated roller 32, which engages with the wings on the escapement crank 28 as this roller moves from one end of the casing to the other. The current from the interlocking machine for operating the motor is cut in and cut out by these switches, the current for one set of field coils being controlled by one switch and for the other set by the other switch.

As there is considerable end thrust when the screw 3 is in operation, means are provided to avoid excessive friction by the use of ball thrust bearings 33 and 33', which are interposed between collars 34 and 34' and the case heads 5. Bushed wire inlets are provided in the casing 1, at 35; these may be placed on either side of the case as occasion requires. A waterproof cover, in which there is a hinged door, is bolted over the top of the casing. The

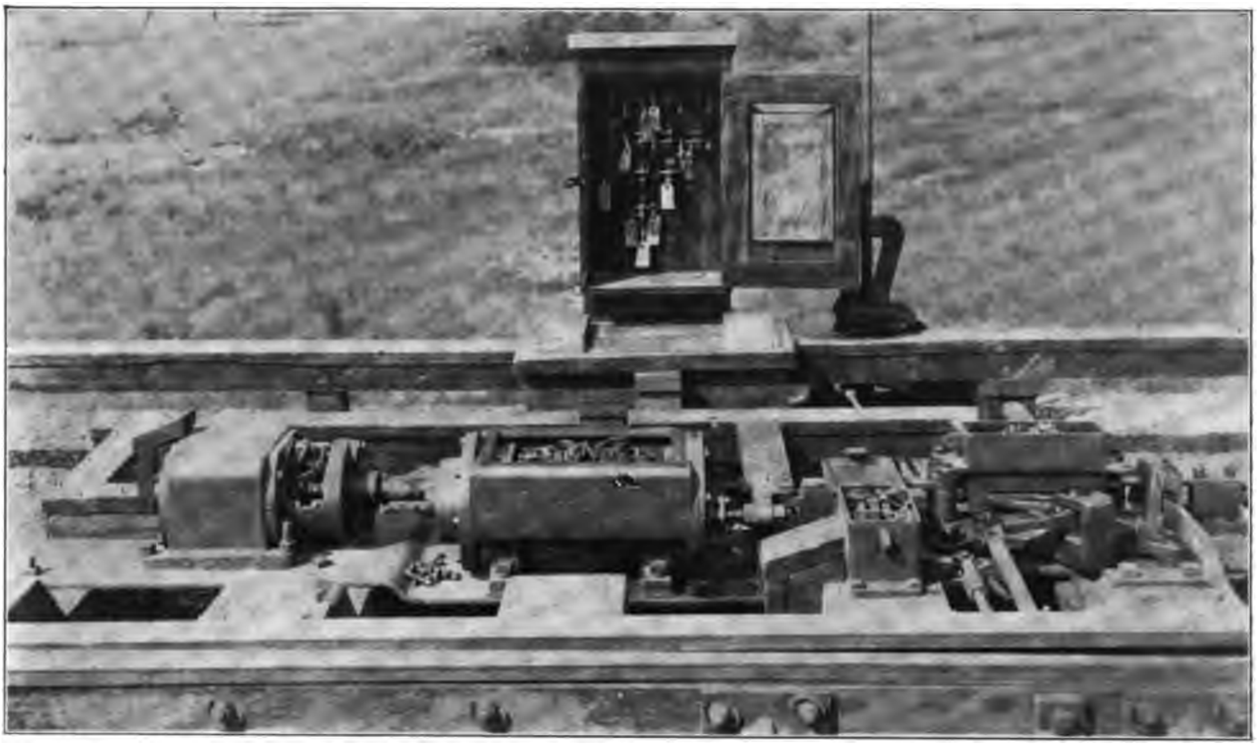


Fig. 1890. Electric Switch and Lock Movement in Place; Covers Removed.

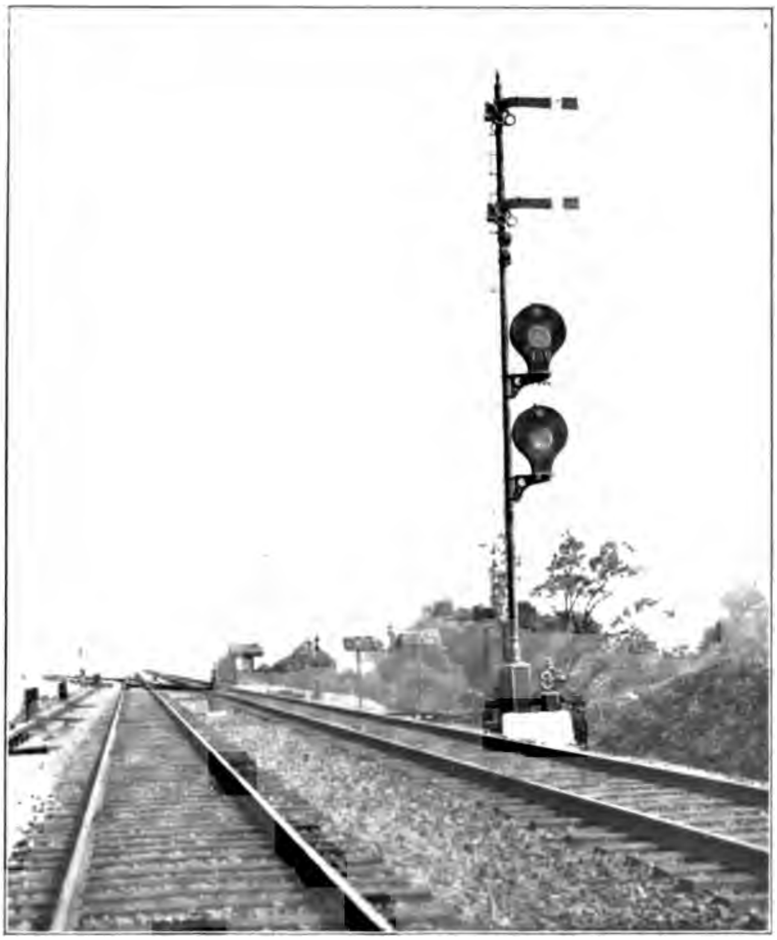


Fig. 1891. Two-Arm Home Signal, with Two Disk Signals on Same Post.

NOTE.—In Fig. 1891, the semaphore arms are interlocking signals and the disks are automatic block signals.

casing is partly filled with lubricating oil to a point just above the bottom of the screw 3, thus insuring thorough lubrication of all working parts of the mechanism.

The operation is as follows: When the motor is connected with the pinion shaft clutch and the current applied to the circuit, the pinion 8 is revolved. This in turn revolves the gear 7 and screw 3; the screw 3 in turn moves nut 11, with yoke 12, and rods 14 and 14′, toward one end of the casing 1. When the roller 32, carried by the rod 14, reaches the wing of the escapement crank it engages with it and moves the toggle point to the opposite side of the center of the switch arm 27, causing the arm to snap open, breaking the motor circuit. The rods 14 and 14′, in operating move the cross head 40, which is attached to the switch and lock movement and thereby throws and locks the switch. If after a complete movement of the apparatus is made, the screw makes a revolution or part of a revolution due to inertia, the yoke 12 will be moved slightly further along the screws. The rods now being stationary, will compress the helical springs against the collars 16, or nuts 18. The springs act with great braking effect thus immediately stopping further rotation of the screw. When the reverse motor circuit is made the apparatus will be operated in a reverse direction in the same manner as described.

The switch and lock movement, Fig. 1883, which is actuated by the switch gear is of the type used in mechanical interlocking. Mounted on the frame of the switch and lock movement, directly over the slide 2 (Fig. 1883) is a device called the indication box, Figs. 1884-1885. This instrument is an iron box 1, with two downwardly projecting flanges which practically enclose the slide of the switch and lock movement so that nothing may be inserted between the slide, and under the side on the box 1. Mounted within the box 1 are two or more sets of springs, 3 and 4, which are arranged to make and break contact when operated.

These contact springs, 3 and 4, are mounted on a block of insulating material 5, which is fastened to the box 1 by screws 6 and 6′. Terminals or binding posts 7 and 7′, are arranged on the springs 4 and 3. Toggle tumblers 8 and 8′ are pivoted in bearings 9 and 9′. Through the upper end of the tumblers extend pins 10, on

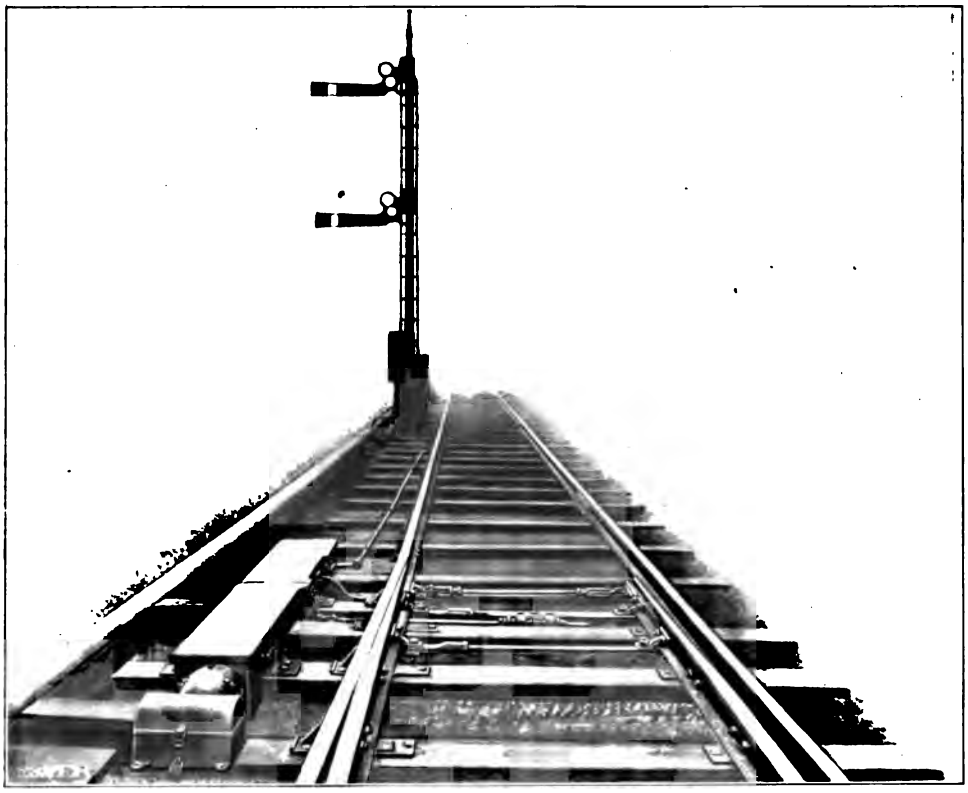


Fig. 1892. Electric Switch Movement and Signal. American Railway Signal Company.

Fig. 1893. Electric Switch Movement; Cover Removed.

each end of which is mounted an insulated roller 11. The pin 10 forms the hinging point of the toggle. The link 12 is also pivoted at its lower end on the pin 10. At its upper end it engages with a tension spring 13, which tends to hold the toggle in the bent position shown. The wings of the tumbler 8 extend below the bottom of the box 1, in the path of a lug 14, which is attached to the side bar 2, of the switch and lock movement, Fig. 1883. Protected openings for wire are provided in the box. The box is also provided with a weather proof cover.

Its operation is as follows: As the slide 2 of the switch and lock movement moves to the left, the lug 14 will engage with the projecting tooth of the tumbler 8, causing the tumbler to revolve on its pivot. When the tumbler moves to a point where the toggle pin 10 gets just beyond the center, the tension spring 13 causes the toggle to snap to a position opposite to that shown. In so doing the insulated roller 11 will strike with considerable force against the springs 3, throwing them into contact with springs 4, and keeping these contacts in this position until the toggle is again

Fig. 1894. Interlocking Machine, Front View.

Fig. 1895. Interlocking Machine, Top and Rear View.

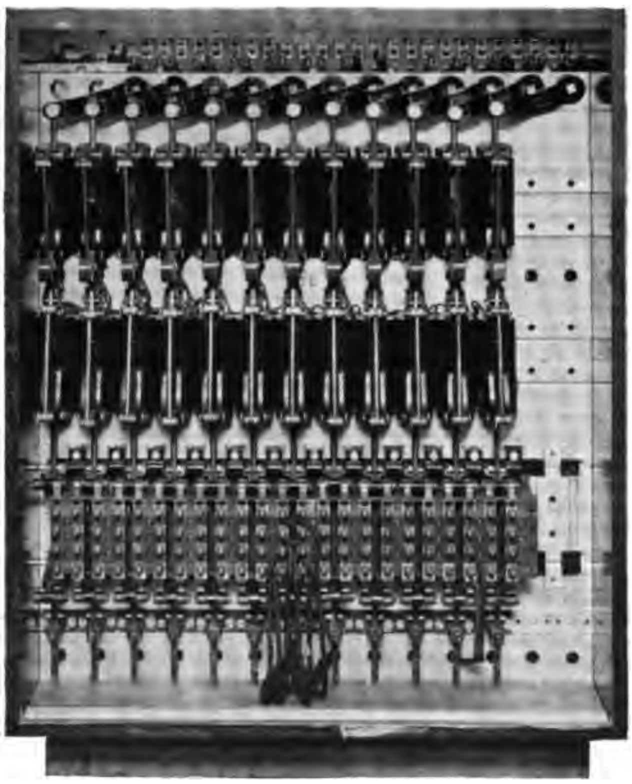


Fig. 1896. Interlocking Machine, Rear View.

tripped in the reverse direction when the springs will snap open again. The contact springs at the other end of the box 1 will be operated in a like manner when the lug 14, on the slide 2, of the switch and lock movement is moved in an opposite direction. The switch and lock movement must be at the extreme end of the stroke before the toggle will change its position, and owing to the design of the switch and lock movement the slide cannot reach this extreme position unless the switch is moved and locked. On the return movement of the slide the toggle is tripped open on the first movement before the unlocking begins. This positively insures the indication circuit making at the last instant of the movement and breaking at the instant of commencing the stroke. A failure of the indication properly to perform its function would result in locking up the controlling lever until the trouble was removed.

The high signal is in all respects similar to the one used in automatic block signaling (see Fig. 446). A view of the signal in the case at an interlocking plant is shown in Fig. 1886.

ELECTRO-PNEUMATIC INTERLOCKING

THE UNION SWITCH & SIGNAL COMPANY.

In this system of interlocking, the operating power is supplied by means of air compressed at some convenient point, stored in one or more reservoirs and conveyed to each function by suitable pipe and hose connections. The control of this power is effected by means of electromagnets, the necessary electric current being obtained from any reliable source, such as primary or storage batteries or from a generator.

The ordinary air pressure used is 70 lbs. per sq. in., although the standard design of apparatus can be made to work satisfactorily with any pressure between 50 and 100 lbs. In order to avoid trouble from moisture condensing and freezing in the small air passages, the air on leaving the compressor is passed through a condenser consisting of a number of cooling pipes (see Fig. 2509) and a large percentage of the moisture is removed. Any remaining moisture is neutralized by alcohol, which is placed in the pipes and reservoir in freezing weather.

The air pressure acts on the piston of a cylinder fixed to the signal post or to the ties near the switch as the case may be. Near each cylinder is a small auxiliary reservoir to provide a sufficient supply of air to insure quick action of the piston at every operation.

The admission and exhaust of air at the cylinder is governed by electromagnetic valves, controlled through wires from the interlocking machine.

In the machine (Figs. 1897-1908) the levers are only a few inches long and very light, their principal work being to open and close electric circuits, and to operate the necessary mechanical locking between each other.

These levers appear as cranks on the front of the machine. Each lever has a latch by which it is held in any desired position, but this latch has nothing to do with the interlocking of one lever with another. Instead of pulling or pushing a lever the signalman turns it to the right or left, and operates a horizontal shaft which revolves on its axis through an arc of 60 degrees. The shaft by means of a rack and pinion actuates miniature Saxby & Farmer locking, differing from that shown in Figs. 665-716 only in size and in the provision made for the movement of signal levers either to the right or to the left of the normal position.

The "indication" from a switch or signal actuates the armature of an electromagnet fixed in the machine, this armature engaging with suitable notches in a segment attached to the shaft of the lever. As arranged with switch levers, this magnet when de-energized locks the shaft after it has been turned far enough to move the switch, and prevents the signalman from completing the stroke of the lever until the switch has finished its movement and is locked in the new position. The indication being received, the stroke of the lever may be completed and (the necessary locking having thereby been released) the lever for the signal, giving a right to proceed over this switch, may be reversed.

To make clear the general principles governing switch and signal operation, Figs. 1909-1916 are presented. The operation of a signal will first be described. Fig. 1909 shows an ordinary lever of a mechanical type arranged to stand normally on center, which has attached to it a circuit controller that closes a circuit operating one signal when moved to the left, and closes a similar circuit for a second signal (conflicting in function with the first) when moved to the right. When the lever is normal both signals are in the stop position and the lever is not engaged by the electric lock. When the lever is reversed to clear a signal, the latter, on leaving the stop position, opens the circuit controlling the lock which immediately engages the lever and prevents its complete return to normal, as illustrated in Fig. 1910. However, the lock permits of a partial return of the lever to normal (Fig. 1911), an amount insufficient to release such mechanical locking as is operated by it (not shown), and which must remain effective until the signal is actually in the stop position. This partial movement of the lever toward normal cuts off the current holding the signal in the proceed position and permits its return by gravity to the stop position. If for any reason it should fail to do so, it is obvious that the lever would be prevented from being put normal, and hence a change of route from the one governed by the deranged signal is prevented. A second lock similarly controlled by the signal in its extreme clear position might be added to detect failures of the signal to clear in response to its lever, but this is not considered necessary on account of the comparatively insignificant results of such a failure. The double reverse movement of the signal levers, besides forming a means of selecting and operating signals, also provides within itself an effective form of locking between two conflicting signals, since one lever cannot assume two positions at the same time.

In adapting the signal lever to the control of the four signals arranged, as shown in Fig. 1912, the wires operating the two opposing signals of Figs. 1909-1911 would be passed through a circuit controller or selector operated by the switch lever or by the switch itself, so that the direction of traffic would still remain under the control of the signal lever, but the signal operated for the route of a direction so selected would be determined by the position occupied by the switch at the time. This arrangement would necessitate extending the circuit of the signal lever lock to the control of the two additional signals, so that any one of the four being operated would produce the same effect on the lock as would either of the two signals of the arrangement shown in Figs. 1909-1911. This extension of the lock circuits is omitted from Fig. 1912 in order that the controlling circuit may be better understood. If we introduce other tracks and switches, and the necessary signals to govern movements from them over the switch shown in Fig. 1912, an extension of the selecting method may be made to include the operation from the same lever of all signals involved; but on condition that the track and traffic conditions never require but one signal to be operated at a time. When two or more signals may be operated simultaneously they, of course, require the use of as many levers. Figs. 1913-1916 show diagrammatically the arrangement of circuits and apparatus used for operating switches. The normal position of the lever is at the extreme left, as shown in Fig. 1913. The circuit controller C-N-L-R controls the circuits affecting the switch valve magnets, and normally current energizes valve magnet N, the other two magnets being de-energized. The effect of this condition is to retain air pressure against the side of the piston which holds the switch in its normal position. The armatures of the indication magnets N and R permit a partial movement of the lever from normal to reverse (that is, sufficient to shift the current

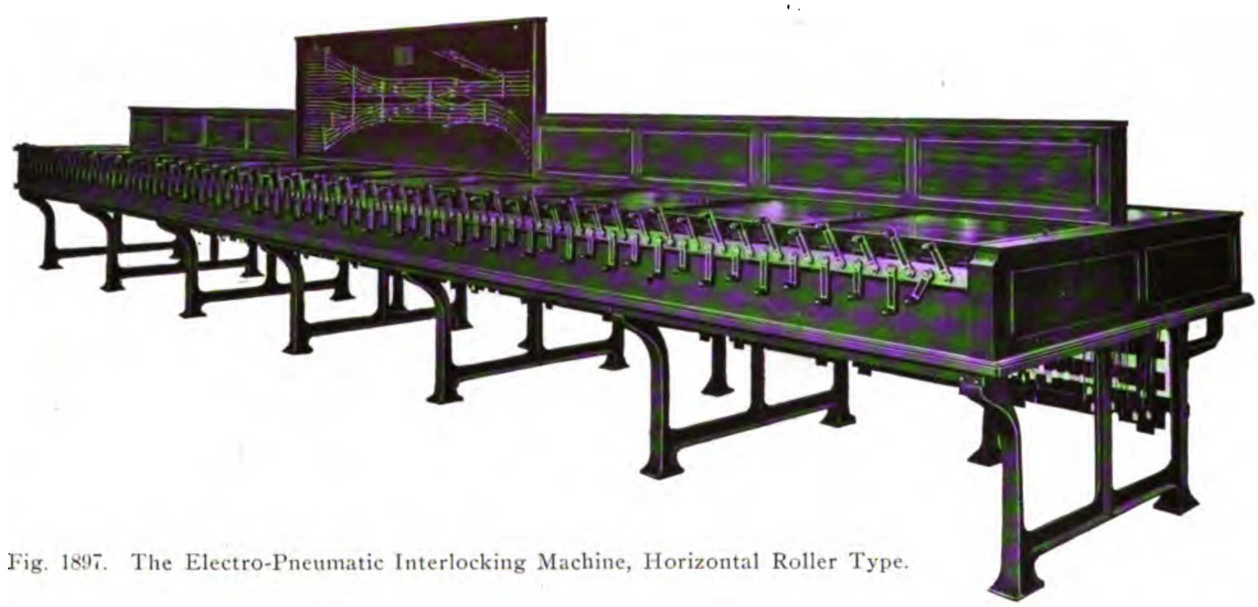


Fig. 1897. The Electro-Pneumatic Interlocking Machine, Horizontal Roller Type.

from valve magnet N to valve magnets L and R), as indicated by dotted lines in Fig. 1913, the effect of which is to de-energize the former and to energize both of the latter. Valve magnet L (known as the lock magnet) is energized at the beginning of the stroke and before current is removed from N; this withdraws the lock controlled by magnet L which holds the switch valve in its normal position. The de-energizing of N and the energizing of magnet R follow immediately. This moves the "D-valve" (19, Fig. 1994), allows the air to escape from the normal side of the piston and admits air from the reservoir on the reverse side of the piston, moving it to the other end of the cylinder and reversing the switch. This partial reversal of the lever can (through the usual mechanical locking provided between switch and signal levers) be made only when all signals, governing movements over the switch to be operated, are in the stop position and when so moved it retains locked all such signals until its complete reversal is effected.

the latter has been released and after the lever has been put into one or the other of its extreme positions. This arrangement is designed to prevent any other than that magnet which corresponds with the position of the switch desired being in circuit at any time (a precaution designed to guard against false indications resulting when the switch is momentarily in one position and the lever is in a semi-reversed position tending to shift it to the other).

The same conditions govern the return of the switch and its lever to normal; but the other pair of indication contacts, N and N, on the switch movement, and the other indication magnet, N, engaging the lever, are brought into use for this purpose. When more than one switch is operated by a single lever, as in the case of a cross-over, the normal and reverse valve magnets at one switch are in series with their corresponding magnets at the other switch, the lock magnets are in multiple, and the indication contacts in series, as shown in Fig. 1916, the valves shifting simultaneously as

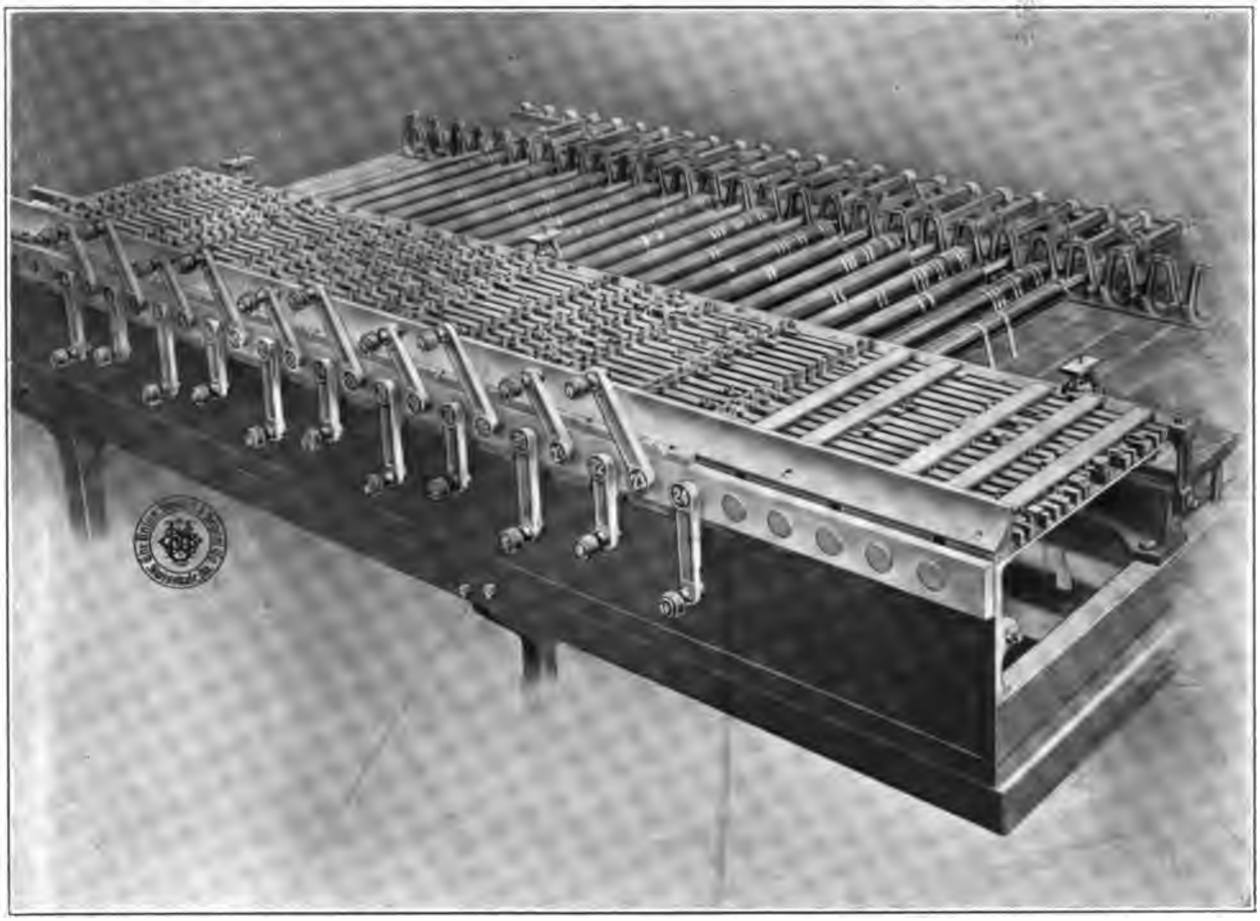


Fig. 1898. Electro-Pneumatic Interlocking Machine; View from Front Showing Locking, Combination Plate and Indication Segments.

Mounted over the switch and lock movement are two pairs of contact springs so arranged that one pair is closed by the slide bar in its extreme normal position (Fig. 1913) and the other pair closed in its extreme reverse position (Fig. 1914). Both pairs of these contacts are open unless the switch is locked in either one position or the other. When the complete movement of the switch is effected and the lock of the switch movement has secured the switch in its reversed position, the plate P is shifted by the movement into contact with springs, R, R. The effect of the circuit thus established on the indication magnet R at the machine (which circuit is formed in part by the wire extending from the machine to the lock magnet L, largely for the sake of economy in wires and for convenience of arrangement) is to energize this magnet, and thereby to lift its armature from longer obstructing the movement of the lever to its extreme reversed position (Fig. 1914). The final movement of the lever may then be made, which releases the mechanical locking that was heretofore in effect, preventing signals from being cleared for movements over the switch, and at the same time shifts the switch controlling contacts to the position shown in Fig. 1915, the effect of which is to remove at once the current from the valve lock magnet, whereupon the switch valve becomes locked in its reversed position; current is also cut off from the indication magnet R and its latch released.

Under the tappet engaged by the latches of the indication magnets is shown a circuit shifter, known as the "quick switch," controlling these magnets. It is moved by the tappet only after a result. Each of the two contacts thus included in the indication circuit closes as its own switch becomes fully moved and locked (this being the case whether these operations occur simultaneously or not), but no indication will be received at the machine unless both switches are locked in the desired position.

The signal used is a semaphore, Figs. 1919-1920, the design being the same used both for interlocking and for block signaling, and is shown in Figs. 454-460. Figs. 1917-1918 show a mechanism designed to operate two arms in three positions, and one arm in two positions. The arrangement shown is for use on a signal bridge where the two-position arm is below the mechanism and operated by the rod extending downward. The three-position arms are situated above the mechanism and operated by the rods extending upward, one for each arm. Each of these rods is provided with two cylinders, as may be seen in Fig. 1917. When air is admitted to one cylinder its piston is raised, raising one rack which moves a pinion through half its travel in the same manner as with the three-position Style "B" motor signal shown in Fig. 427, causing the arm to assume its intermediate or "caution" position. When the second piston is raised the pinion is again moved upward, completing the movement of the arm to the clear position. The mechanism may be provided with special piping so that the air supply for the third position passes through the second position valve. Circuit controller attached to hard rubber cylinders may be seen at each side of the mechanism in Fig. 1917.

In the dwarf semaphore (Figs. 1936-1937) the return of the

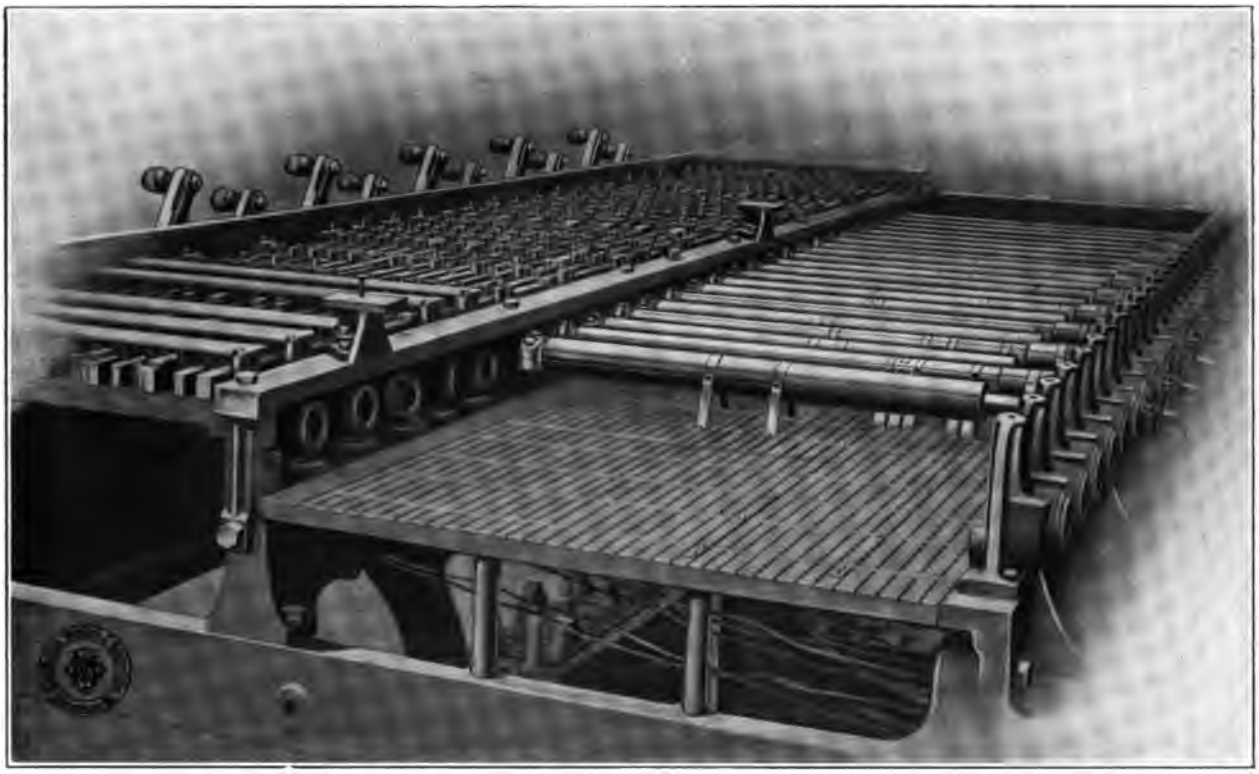


Fig. 1899. Electro-Pneumatic Interlocking Machine, Horizontal Roller Type; View Showing Side Elevation.

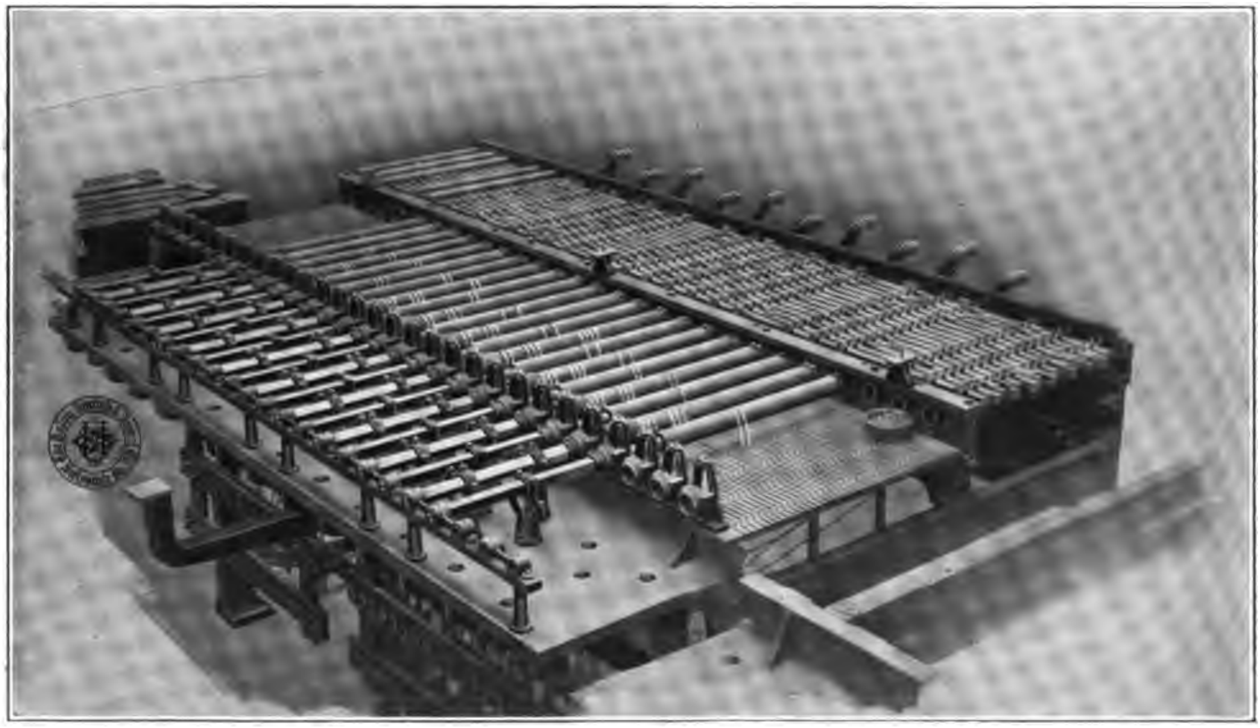


Fig. 1900. Electro-Pneumatic Interlocking Machine; View from Rear Showing Locking, Combination Plate and Indication Segments.

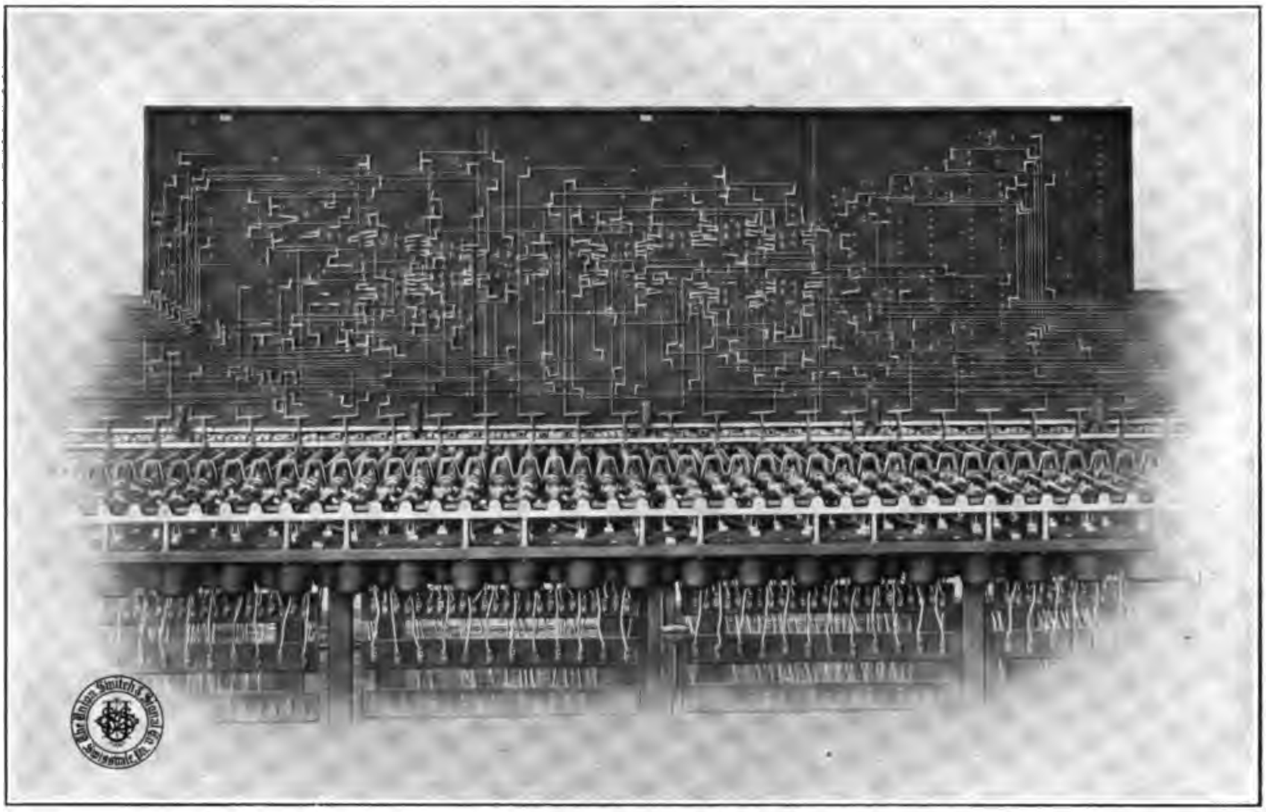


Fig. 1901. Electro-Pneumatic Interlocking Machine; Rear View of Track Model.

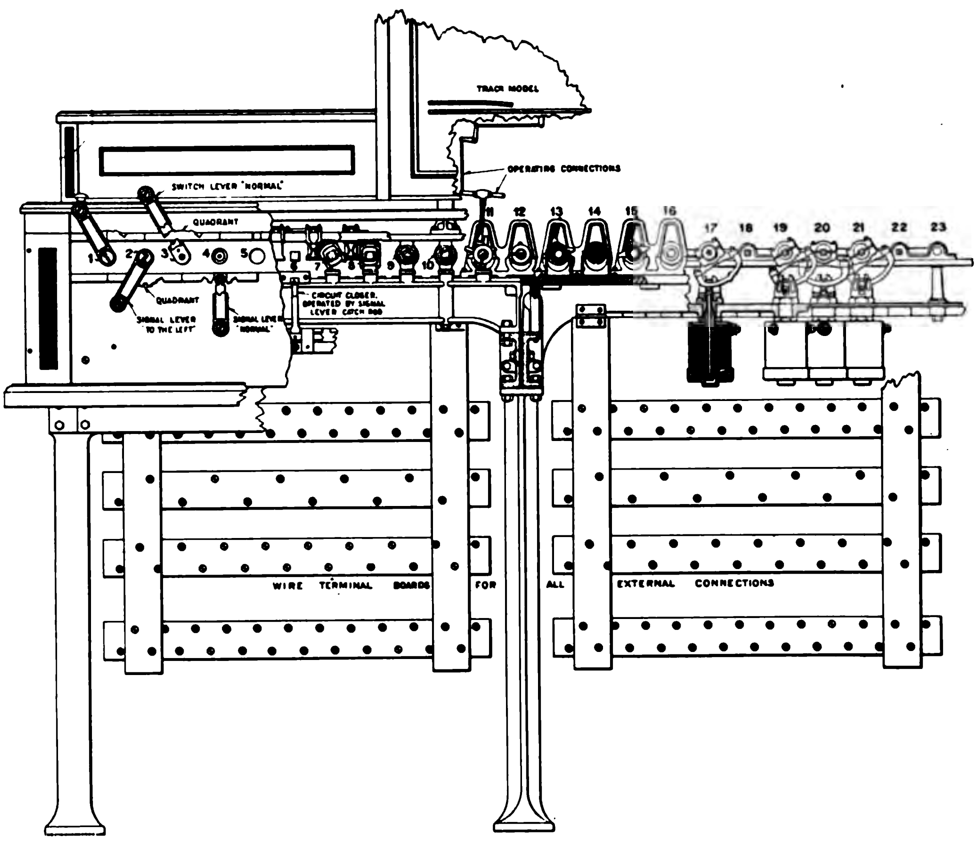


Fig. 1902. Electro-Pneumatic Interlocking Machine; Front Elevation Partly in Section.

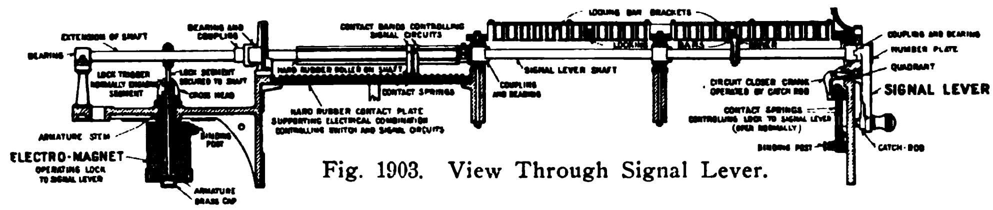


Fig. 1903. View Through Signal Lever.

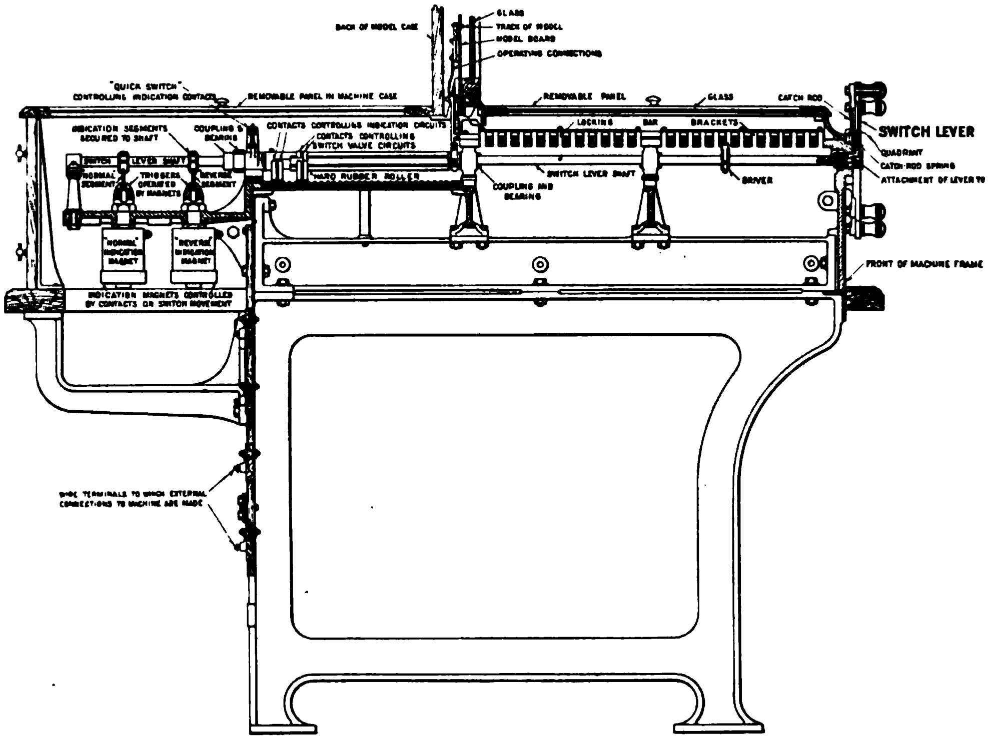


Fig. 1904. View Through Switch Lever.

Figs. 1903-1904. Sectional Views of Electro-Pneumatic Interlocking Machine.

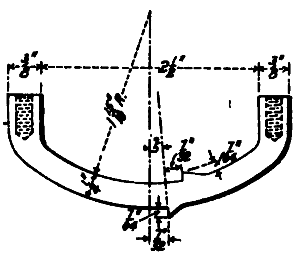


Fig. 1905. Indication Segment for Switch Lever.

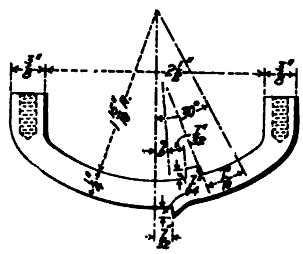


Fig. 1907. Indication Segment for Signal Lever.

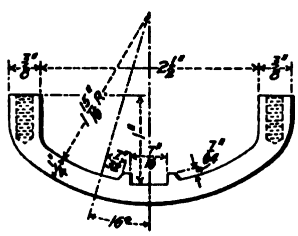


Fig. 1906. Indication Segment for Switch Lever, with Electric Detector Circuits.

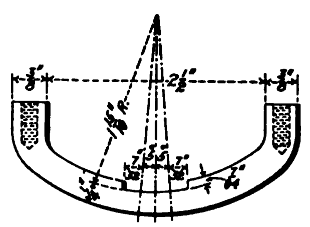


Fig. 1908. Indication Segment for Traffic Lever (Check Locking).

arm to the stop position is secured by the use of the spring 8, instead of by a weight such as is used in the high semaphore. The cylinder is movable and the piston stationary, the air pressure pushing up the cylinder against the downward pressure of the spring. This movement causes the arm to assume the clear position, and on the release of the air, when the signal is to be restored to the stop position, the spring forces the cylinder and connecting rod downward. The piston rod is hollow, thus serving as a port for the admission of air to the cylinder and also for exhaust. If the spring should fail to restore the signal to the stop position, the signal lever would be held by the indication lock, preventing its full return to the normal position, thus compelling attention to the defect in the signal. The indication contacts are closed by a metal strip (27, Fig. 1937) mounted on an insulated contact block attached to the cylinder. Thus the indication circuit is open unless the arm is in the stop position.

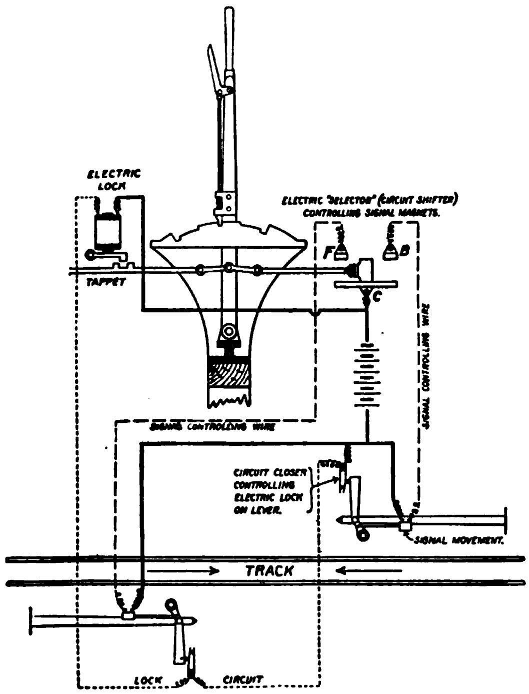


Fig. 1909. Signal Lever in Normal Position; Signals at Stop; Lever Free to Clear Either Signal.

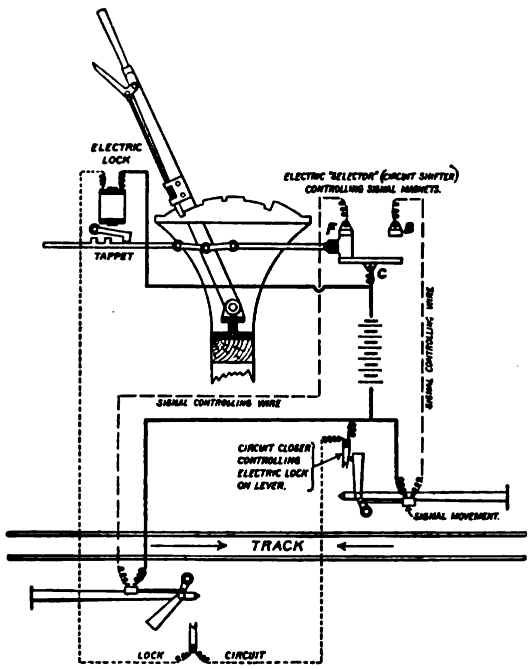


Fig. 1910. Signal Lever Reversed to the Left; One Signal at Proceed; Signal Lever Locked, Preventing Full Movement to Normal.

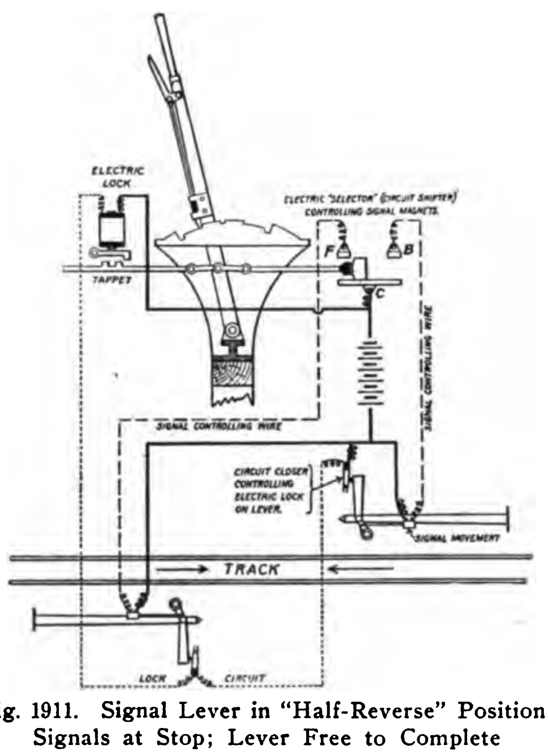


Fig. 1911. Signal Lever in "Half-Reverse" Position; Signals at Stop; Lever Free to Complete Movement to Normal.

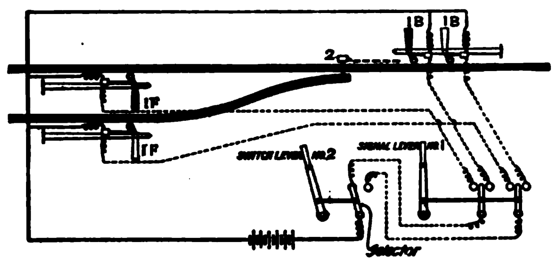


Fig. 1912. Track and Signal Layout; Selected Signals.

Figs. 1940-1941 show a suspended semaphore arm operated by a cylinder situated above. This is the standard arrangement for route signals on some roads. It is also convenient for use as a starting signal from terminal train sheds, where it may be attached to the building above the track.

Fig. 1942 shows a rotary pot signal designed to be placed between tracks where there is very little clearance; the cylinder is placed in a horizontal position and moves the lamp and disks by a crank. They are restored to the stop position by the spring operating under the same conditions as in the dwarf signal.

Portions of the electro-pneumatic interlocking machine are shown in Figs. 1898-1908, Figs. 1903-1904 being a section from back to front. The track model, a feature of this machine, appears in section in the upper part of Figs. 1902 and 1904. It consists of metal strips representing a plan of the track. Each portion which represents a switch is movable, and is connected to the switch levers in such a way that every movement of the lever to move a switch in the track moves the corresponding part of the model (see Fig. 1901). Some models have miniature signals as well as tracks.

The principal parts of the interlocking machine are indicated in the transverse section, Fig. 1902. The mechanical interlocking parts, supported by the locking bar brackets, are similar in design to the interlocking shown in Figs. 665-716. The whole apparatus is inclosed in a wooden case with glass top. The wire connections (not shown in the drawings), are all run to binding posts on the rear of the frame supporting the machine.

The process of operating a switch lever may be briefly described as follows, taking, for example, lever No. 3, Fig. 1902. All signals which could give a clear route over the switch in its present position being in the stop position, so that the interlocking will not interfere with the intended movement, the signalman moves the lever to the right, revolving the shaft. As soon as this revolution has begun the driver on the shaft (see Figs. 1903-1904) has moved the locking bar a short distance, so as to lock all levers which, if moved, would permit trains to interfere with the intended movement. This locking effected, the further revolution of the shaft causes bronze strips to close the switch valve circuits, which admit air to the switch cylinder. The piston movement produced by this air pressure unlocks the switch, moves it to the other position, and then locks it. The locking of the switch having been completed, the closing of the contact in the indication box energizes its proper indication magnet in the machine, and the signalman is then able to complete the stroke of his lever, leaving it inclined to the right. This final movement pushes the locking bar the remainder of its stroke and unlocks the lever or levers by which the signalman will clear the signal to permit a train to pass over the switch in its new position.

The switch cylinder is shown in Fig. 1943. Each cylinder, by means of its piston, moves the switch, detector bar and lock; also two or more switches near together may be moved by the same cylinder where it is found desirable to do so (see Fig. 1944). This multiplication of functions is provided for by an increase in the size of the cylinder or by a higher air pressure.

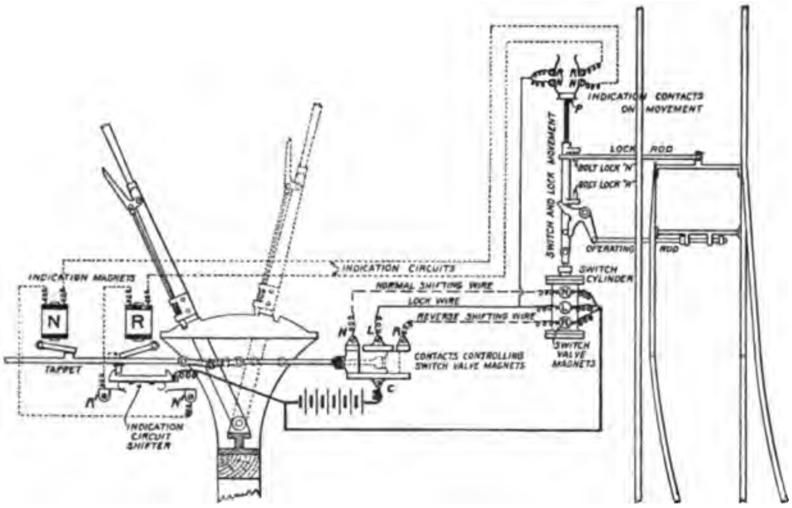


Fig. 1913. Switch Lever in Normal Position; Dotted Lines Show Preliminary Movement Made by Lever in Reversing the Switch; Switch Has Not Started to Move.

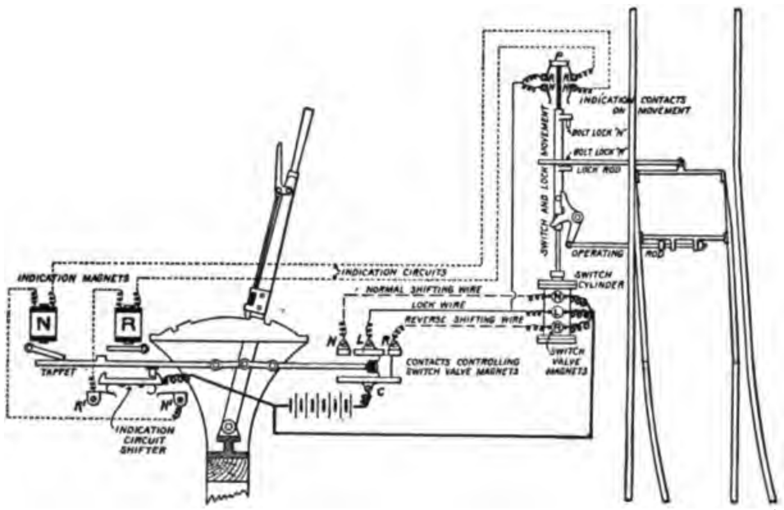


Fig. 1914. Switch Lever Against Reverse Indication Stop; Switch Has Moved and Become Locked in Reverse Position; Lever Has Been Released by Indication Lock for Final Movement to Full Reverse Position.

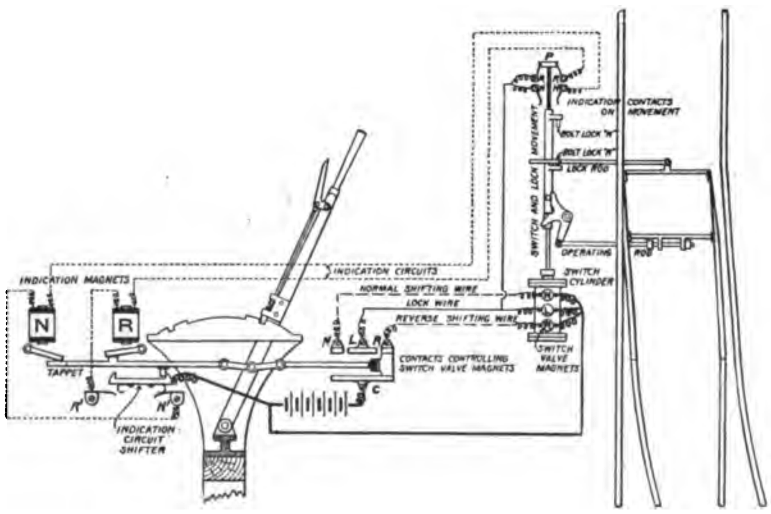


Fig. 1915. Switch Lever in Reverse Position; Indication Latch Released; "Quick Switch" in Position to Receive Normal Indication.

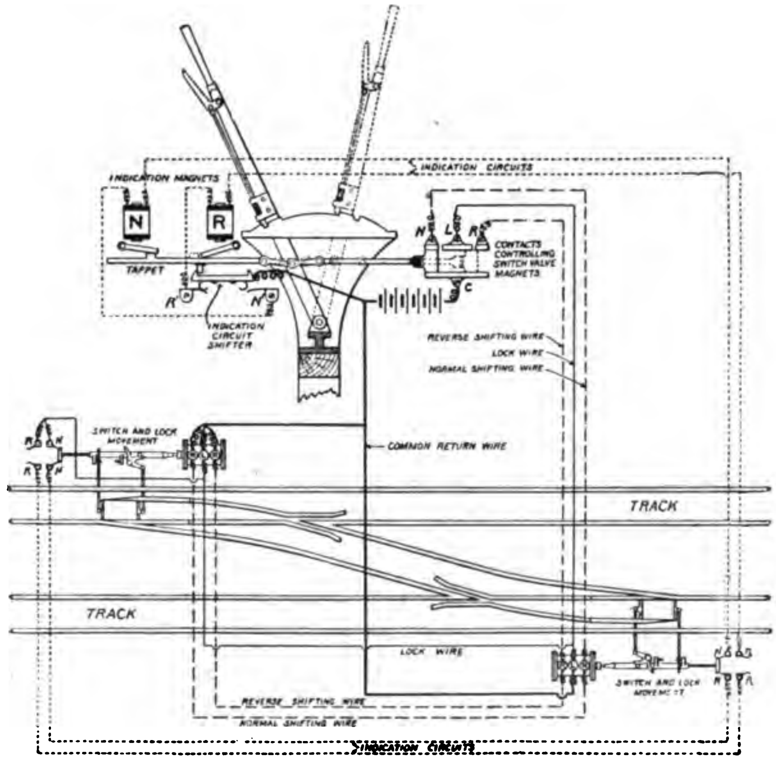
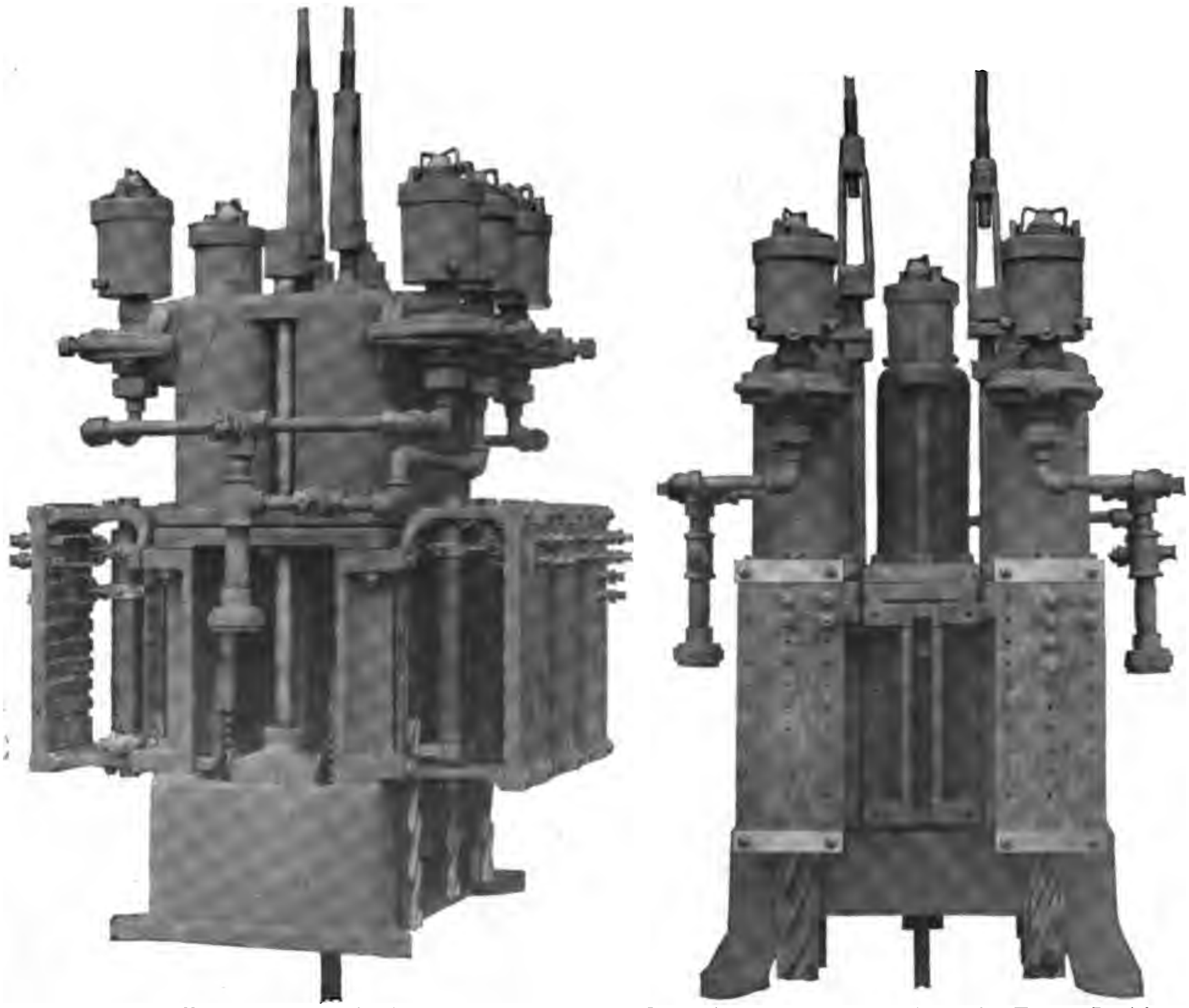
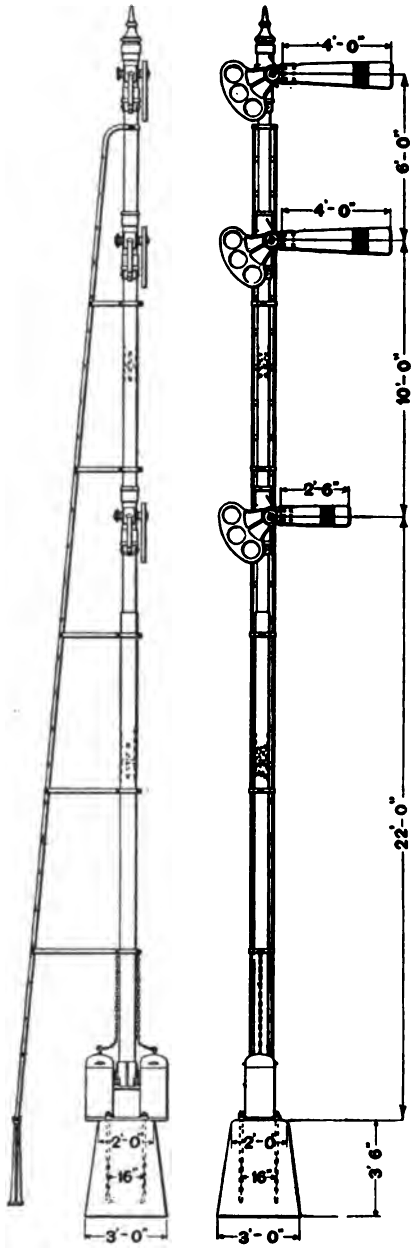


Fig. 1916. Switch Lever and Connections Arranged to Operate a Crossover.



Figs. 1917-1918. Electro-Pneumatic Signal Mechanism for Operating Two Arms Above in Three Positions, and One Arm Below in Two Positions. Pennsylvania Railroad.

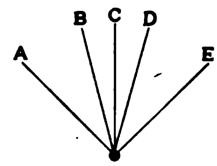


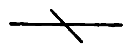
Figs. 1919-1920. Three-Arm Electro-Pneumatic Signal. Pennsylvania Railroad.

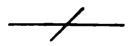
In Figs. 1943-1948 is shown the switch and lock movement by which the rod from the cylinder performs the double function of moving the switch and locking it. This device is similar in principle to the locking apparatus used with other kinds of interlocking where such a combination of functions is desired. The principal parts are so lettered as to explain their use. The flexible connection from the auxiliary reservoir to the cylinder is employed to provide against undue strain on the pipe connections on account of settling of the different parts. The piston rod and the slide bar of the switch and lock movement, together with the detector bar connection, are permanently connected and may be treated as a single rod. This rod has a stroke of eight inches; but its action on the switch, by means of the escapement crank, does not begin until it has moved about 2 inches; and the switch action is finished in the next 4 inches of the movement; so that the first 2 inches can be used to unlock the switch and the last 2 inches to lock it in its new position. The lock rod, where it passes through the frame, appears in elevation, as in Fig. 1948. The slide unlocks the switch by withdrawing a lug from the lower notch *y* (which lug is indicated in Fig. 1947 by dotted lines), and locks the switch after moving it (and changing the position of the lock rod) by pushing another lug into the upper notch *x*. The vertical pin in the slide bar which moves the escapement crank is fitted with a loose collar.

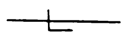
Figs. 1949-1950 show the details of the switch valve. The admission and exhaust of air to and from the cylinder is con-

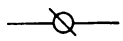
Contacts for Switch Levers.

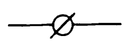


 Contact Closed When Lever is Normal.

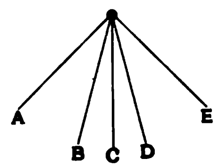
 Contact Closed When Lever is Reversed.

 Contact Closed Except in Extreme Position of Lever.

 Contact Closed When Lever is Normal and until It Has Just Passed Center. See A D Above.

 Contact Closed When Lever is Reversed and until It Has Just Passed Center. See B E Above.

Contacts for Signal Levers.



A *Extreme Left.*
B *Against Quadrant Stop to Left.*
C *Middle.*
D *Against Quadrant Stop to Right.*
E *Extreme Right.*

L — Contact Closed at A.

R — Contact Closed at E.

NL — Contact Closed at C, between C and A, and at A.

NR — Contact Closed at C, between C and E, and at E.

SN — Contact Closed except in Both Extreme Positions of Lever.

SL — Contact Closed at A, between A and B, and at B.

SR — Contact Closed at E, between E and D, and at D.

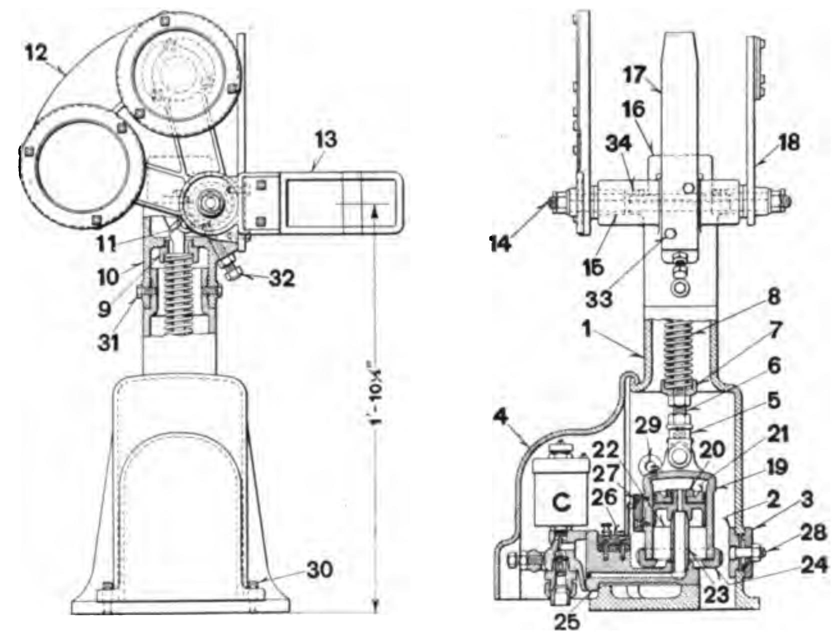
AD — Contact Closed at A, between A and D, and at D.

BE — Contact Closed at B, between B and E, and at E.

D — Contact Closed at D only.

B — Contact Closed at B only.

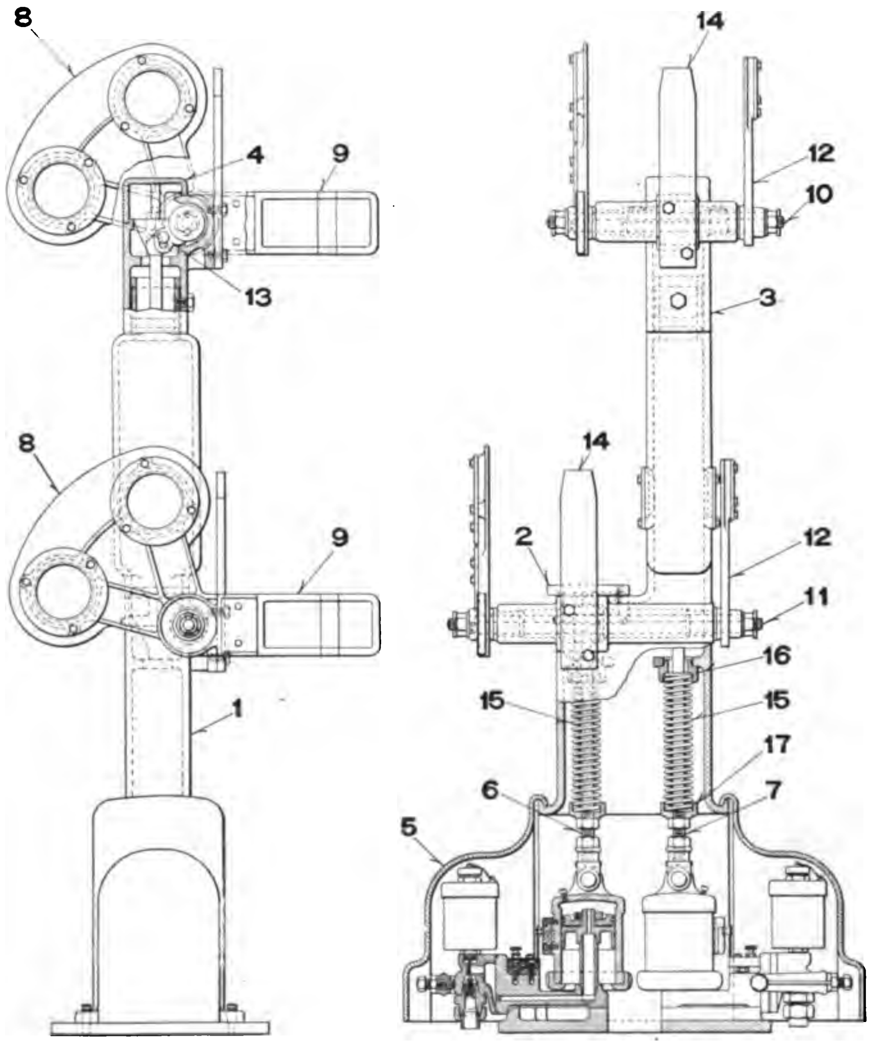
Figs. 1921-1935. Symbols Used on Circuit Drawings for Electro-Pneumatic Interlocking.



Figs. 1936-1937. One-Arm Electro-Pneumatic Dwarf Signal.

Names of Parts of One-Arm Electro-Pneumatic Dwarf Signal; Figs. 1936-1937.

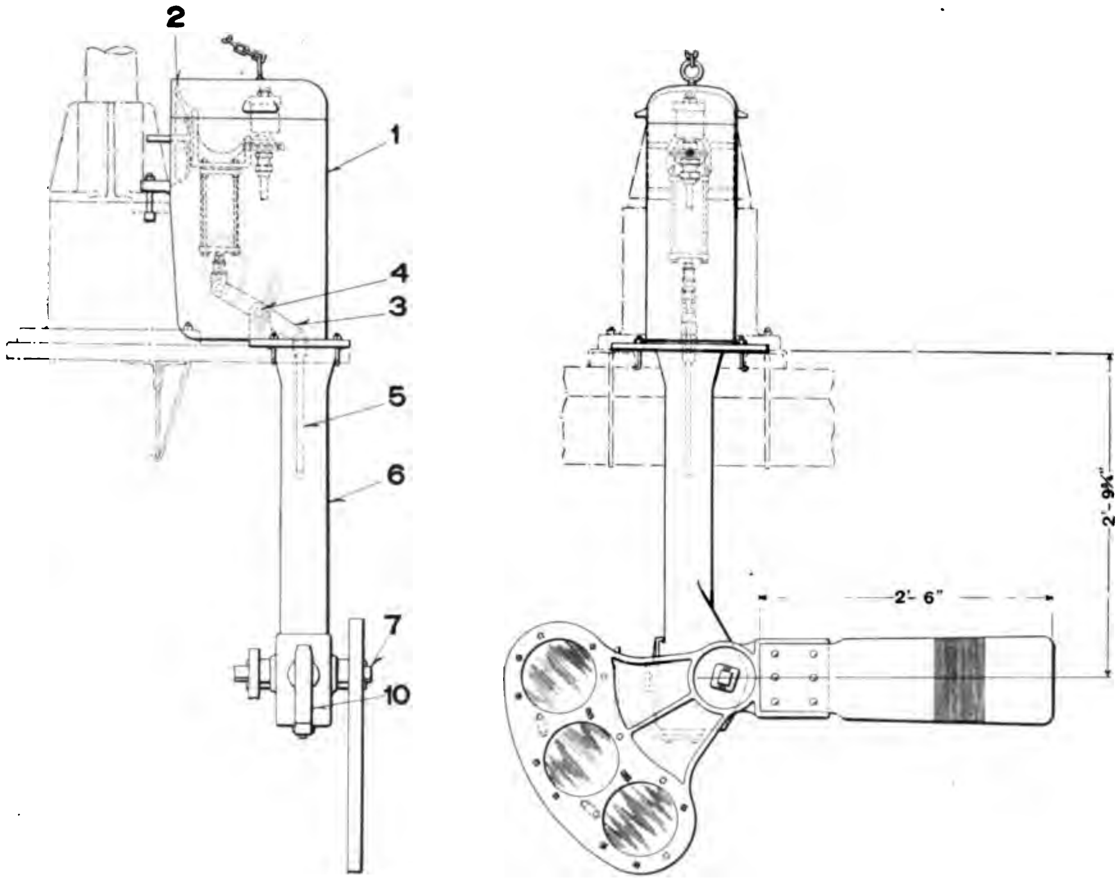
1 *Post and Base*
2 *Inside Plug for Opening for Mechanical Connection. (See Figs.* 1548-1552.)
3 *Outside Plug for Opening for Mechanical Connection.*
4 *Mechanism Cover*
5 *Jaw*
6 *Up and Down Rod*
7 *Bottom Spring Socket*
8 *Restoring Spring*
9 *Top Spring Socket*
10 *Semaphore Bearing*
11 *Semaphore Crank*
12 *Spectacle,* 60°
13 *Blade*
14 *Semaphore Shaft*
15 *Journal for* **14**
16 *Cap*
17 *Lamp Bracket*
18 *Back Spectacle*
19 *Cylinder*
20 *Nut for Fastening Piston Ring Cage.*
21 *Cage for Piston Rings*
22 *Piston*
23 *Hollow Piston Rod and Air Inlet*
24 *Cylinder Cap*
25 *Valve Base*
26 *Circuit Breaker Springs and Base*
27 *Contact Block and Strip*
28 *Bolt for* **2** *and* **3**
29 *Hole for Crank Pin. (See Figs.* 1548-1552.)
30 *Dowel Pins*
31 *Cap Screw.*
32 *Semaphore Adjusting Screw*
33 *Tap Bolt*
34 *Screw for Cap*
C *Pin Valve Magnet*



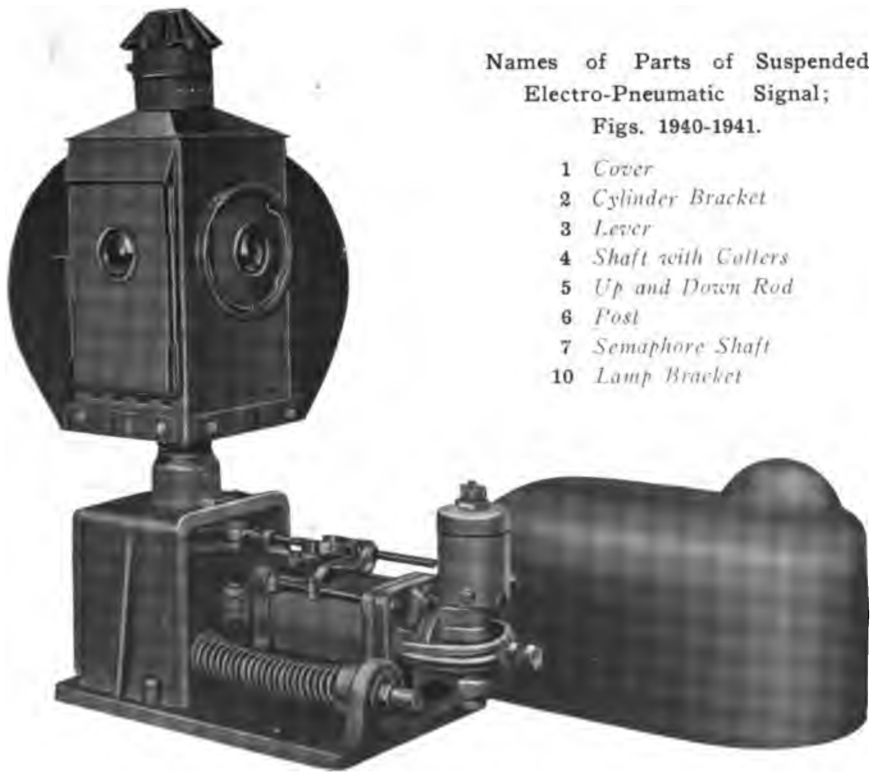
Figs. 1938-1939. Two-Arm Electro-Pneumatic Dwarf Signal.

Names of Parts of Two-Arm Electro-Pneumatic Dwarf Signal; Figs. 1938-1939.

1 *Post and Base*
2 *Cap for Lower Semaphore Bearing*
3 *Semaphore Bearing*
4 *Cap for Upper Semaphore Bearing*
5 *Mechanism Cover*
6 *Up and Down Rod, Lower Arm*
7 *Up and Down Rod, Upper Arm*
8 *Spectacle,* 60°
9 *Blade*
10 *Semaphore Shaft, Upper Arm*
11 *Semaphore Shaft, Lower Arm*
12 *Back Spectacle*
13 *Semaphore Crank*
14 *Lamp Bracket*
15 *Restoring Spring*
16 *Top Spring Socket*
17 *Bottom Spring Socket*



Figs. 1940-1941. One-Arm Electro-Pneumatic Suspended Route Signal.



Names of Parts of Suspended Electro-Pneumatic Signal; Figs. 1940-1941.

1 *Cover*
2 *Cylinder Bracket*
3 *Lever*
4 *Shaft with Collars*
5 *Up and Down Rod*
6 *Post*
7 *Semaphore Shaft*
10 *Lamp Bracket*

Fig. 1942. Electro-Pneumatic Rotary Pot Signal.

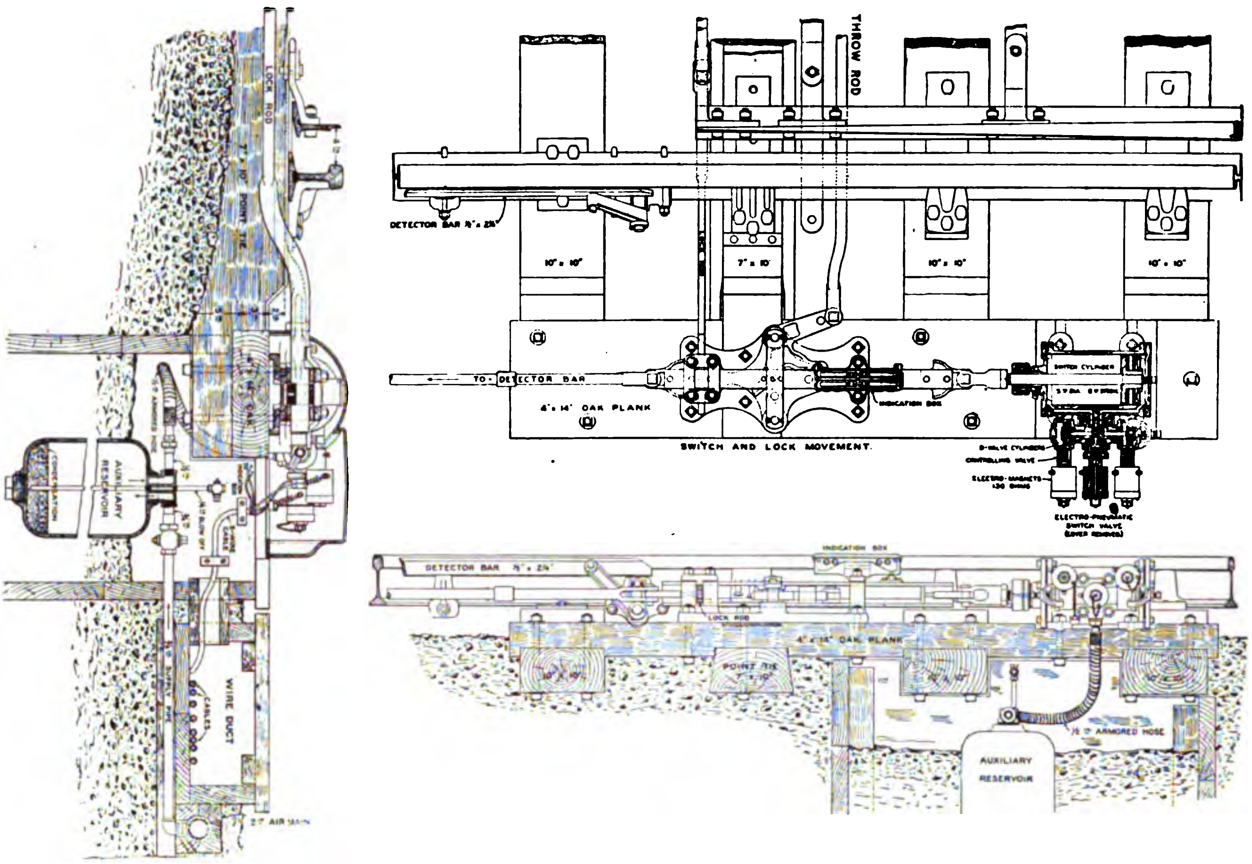
Fig. 1943. Electro-Pneumatic Switch and Lock Movement Attached to Bed-Plate.

Fig. 1944. Electro-Pneumatic Tandem Switch and Lock Movement for Use with Movable Frogs.

trolled by the D-valve 19, in the same manner as is done by the ordinary slide vale of a steam engine. This valve is operated by two small pistons, one on each side, which are in turn controlled by the pin valves of the normal and reverse magnets, the same as in the signal mechanism, explained in connection with Fig. 457. The lock magnet in the center controls a bolt which engages the D-valve in each of its extreme positions. When the magnet is energized the spring 16 is compressed and the bolt withdrawn, allowing the D valve to be moved. Thus it is necessary to have one magnet de-energized and the other two energized before the switch will be moved.

For the Subway Division of the Interborough Rapid Transit Company, owing to the restricted clearances, it was found necessary to redesign some of the electro-pneumatic interlocking apparatus. It was necessary to mount the controlling valve magnets for the switch cylinders on the cylinder head and also to design a motion plate switch and lock movement. In some cases, also, the switch valves were mounted on a separate base several feet away from the cylinder. The special switch and lock movement is shown in Figs. 1957-1958. It was found that in many cases there was not sufficient space to install the electro-pneumatic interlocking machine with horizontal rollers as usually made. A machine was therefore designed with vertical rollers, Figs. 1951-1952, which is very compact. The interlocking signals used in the Subway are of the same design as those used for block signaling shown in Figs. 537-538 and 540-541. The dwarf signal is shown in Fig. 1953.

Figs. 1954-1955 show what is known as the push button electro-pneumatic interlocking machine. This is employed like the dwarf interlocking machine where a number of switches are concentrated in a yard where all the movements are low speed and no interlocking is required between levers, the machine being employed merely to reduce the number of men necessary to operate the switch. This machine is so arranged that pressing of one button will reverse the switch, and pressing of another button will put it normal again. Figs. 1959-1960 show a switch arranged to be used with this type of machine, and the circuits for operating it



Figs. 1945-1947. Electro-Pneumatic Switch and Lock Movement Applied to Single Switch with One Detector Bar Ahead of Points; Cylinder and Movement Set on Plank.

NOTE.—In latest construction an iron bed-plate is used, which requires less cutting of the ties. (See Figs. 1943 and 1956.)

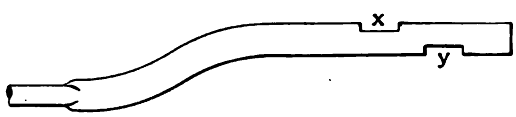
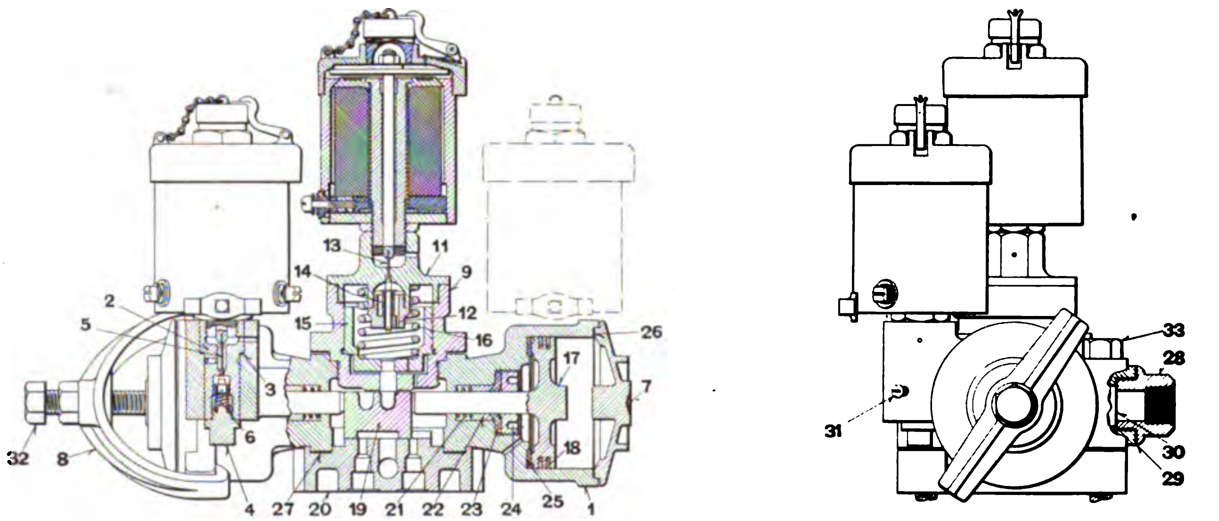


Fig. 1948. Lock Rod, for Figs. 1945-1947.

Names of Parts of Electro-Pneumatic Switch Valve; Figs. 1949-1950.

1 *Valve Chamber*
2 *Guide for Pin Valve*
4 *Pin Valve Plug*
5 *Pin Valve*
6 *Pin Valve Spring*
7 *Head for Valve Chamber*
8 *Yoke*
9 *Lock Cylinder*
11 *Head for Lock Cylinder*
12 *Pin Valve Guide for Lock Cylinder*
13 *Pin Valve for Lock Cylinder*
14 *Pin Valve Spring for Lock Cylinder*
15 *Piston for Lock Cylinder*
16 *Spring for Lock Cylinder*
17 *Piston for Switch Valve*
18 *Piston Rings for* **17**
19 *D-Valve*
20 *Valve Seat*
21 *Spring for Stuffing Box*
22 *Gland for Stuffing Box*
23 *Packing for Stuffing Box*
24 *Nut for Stuffing Box*
25 *Gasket for Piston Seat in Valve Chamber*
26 *Gasket for Head of Valve Chamber*
27 *Gasket for Valve Seat*
28 *Union for Valve Chamber*
29 *Washer for* **28**
30 *Strainer for* **28**
31 *Oil Plug*
32 *Tap Bolt for Yoke*
33 *Tap Bolt for Fastening Valve Chamber and Seat to Cylinder*



Figs. 1949-1950. Electro-Pneumatic Switch Valve.

Figs. 1951-1952. Electro-Pneumatic Interlocking Machine; Vertical Roller Type.

Fig. 1953. Electro-Pneumatic Dwarf Slide Signal. Interborough Rapid Transit Company.

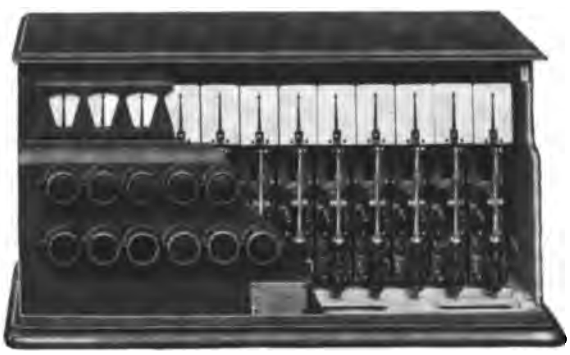


Fig. 1954. Electro-Pneumatic Push Button Machine.

Fig. 1955. One Section of Mechanism, Fig. 1954, Electro-Pneumatic Push-Button Machine.

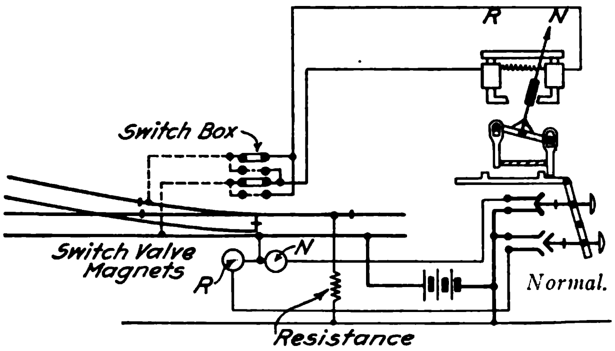


Fig. 1956. Diagram of Typical Circuits for Operating Switches from Electro-Pneumatic Push-Button Machine.

Fig. 1957. Electro-Pneumatic Motion Plate Switch and Lock Movement.

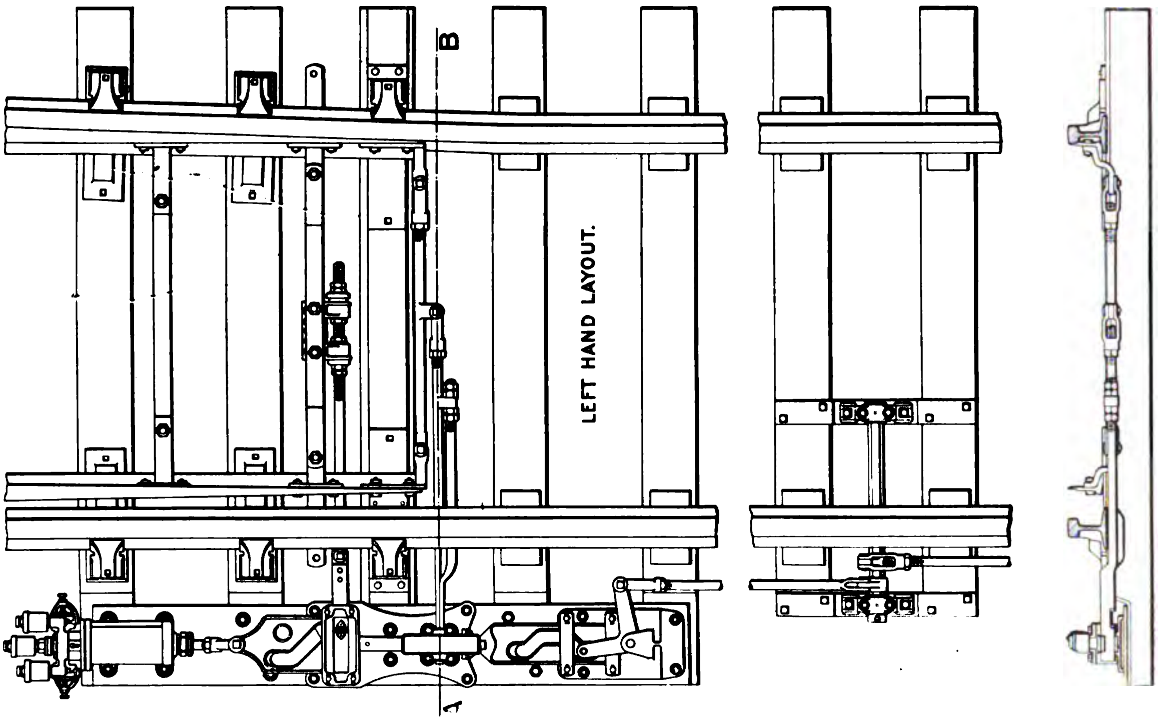


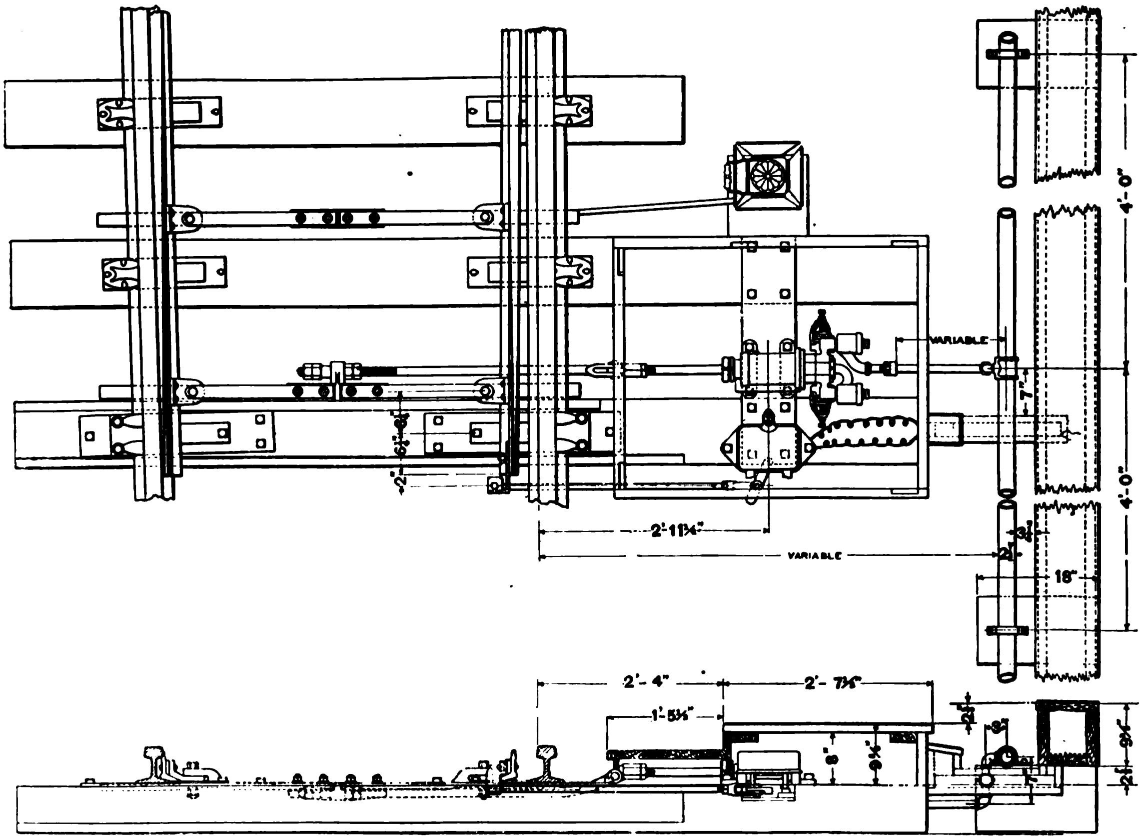
Fig. 1958. Electro-Pneumatic Motion Plate Switch and Lock Movement and Detector Bar Movement, Applied to a Single Switch, with One Detector Bar Ahead of Points; Adjustable Lock Rod.

are shown in Fig. 1956, which also shows a track circuit and electric lock used in place of a detector bar.* The switchbox is a pole changer and the electric lock is polarized.

Fig. 1961 is a diagram of the tracks and signals at the South Terminal Station, Boston, which are operated by the machine shown in Fig. 1897.

Fig. 1965 shows the arrangement of circuits and apparatus for controlling the drawbridge over the Charles River, where it is crossed by the Boston Elevated Railroad. Attached to the structure is a circuit controller F, which closes the circuit energizing the draw indicator only when the draw is in proper position, both with respect to its vertical and horizontal alinement. In series with this is another contact G, which insures the proper position of the wedges supporting the draw ends before the circuit is closed. When this circuit is complete the draw indicator clears, permitting the operation of the draw lock by reversing lever 21, and also permitting signals 18-L and 20-R to be cleared for traffic. These signals are also interlocked with lever 21. When it is desired to open the draw (signals 18-L and 20-R being set in the stop position), lever 21 is moved to normal, withdrawing the draw lock, which is operated by the plunger cylinder C. When this lock is withdrawn circuit controller B closes a local circuit which energizes lock L on the draw tender's gearing, releasing same and permitting him to open the draw.

*Note.—For electric detection applied to electro-pneumatic interlocking see Figs. 2009-2010.



Figs. 1959-1960. Direct Acting Electro-Pneumatic Switch Movement Layout for Single Switch Without Detector Bar.

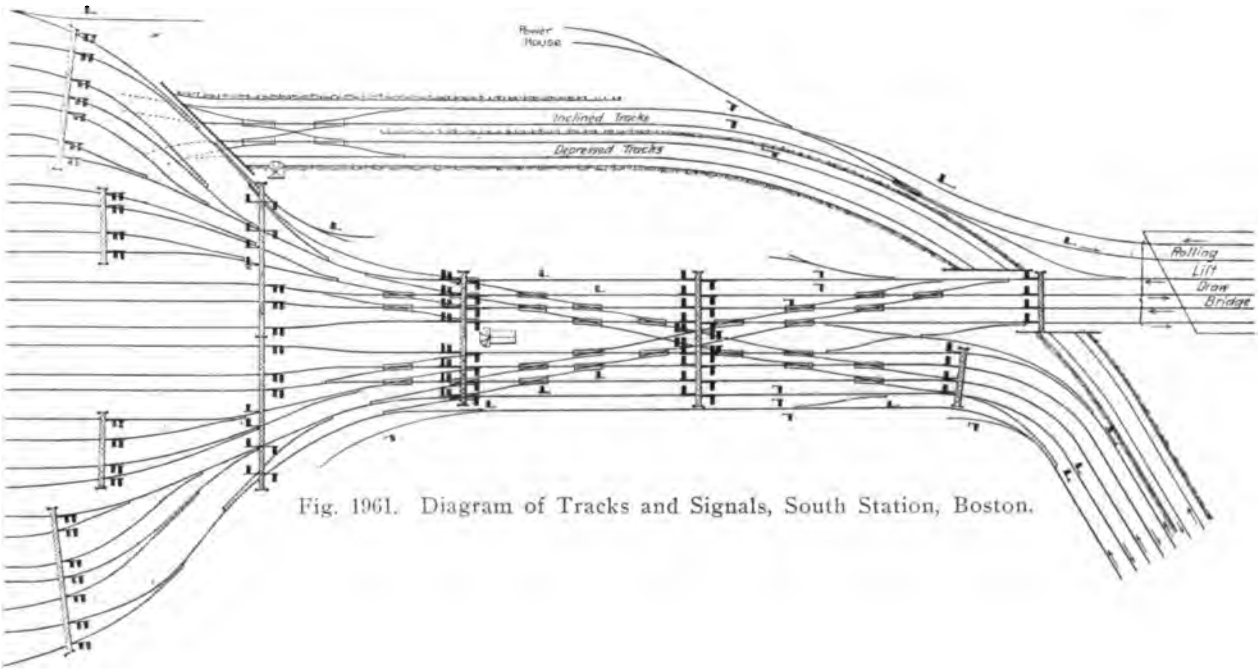
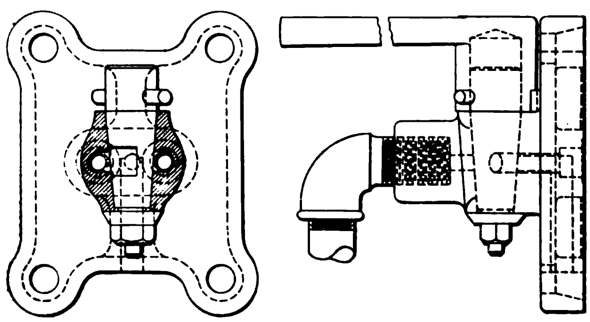


Fig. 1961. Diagram of Tracks and Signals, South Station, Boston.



Figs. 1962-1963. Three-Way Valve, Used for Operating Electro-Pneumatic Switches by Hand During Installation of Plants Under Traffic.

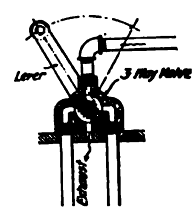
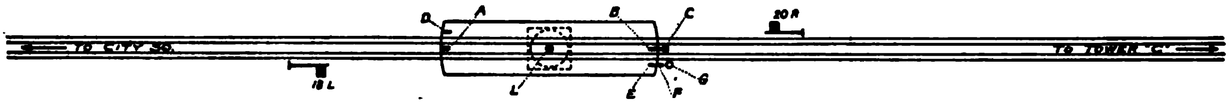
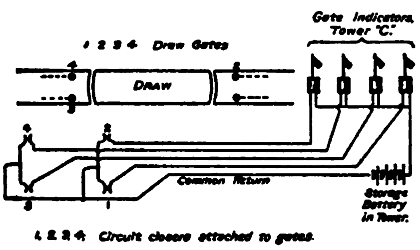


Fig. 1964. Diagram Showing Operation of Valve Shown in Figs. 1962-1963.



Circuits Controlling Gate Indicators.



Circuits Controlling Draw Lock and Signals.

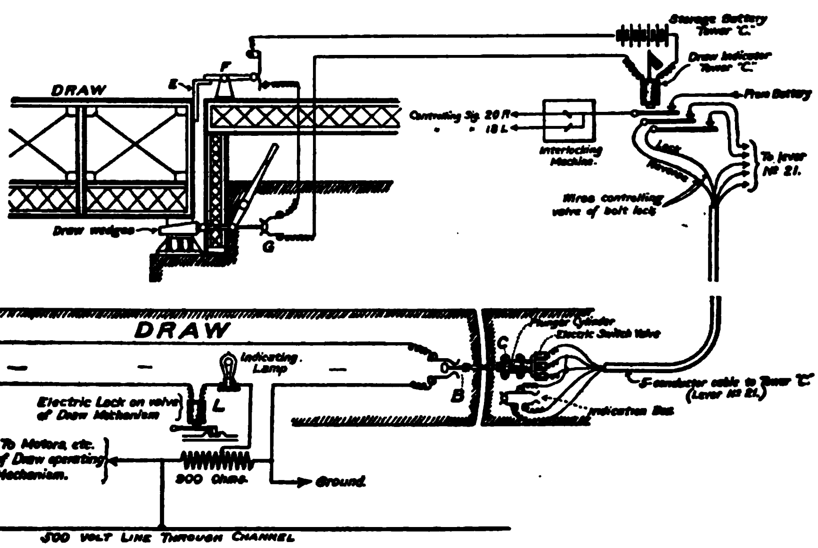


Fig. 1965. Circuits for Drawbridge Protection. Boston Elevated Railroad.

Names of Parts of Fig. 1965.

A B	*Circuit Closer and Bridge Bolt Keeper*
C	*Electro-Pneumatic Bridge Lock Plunger*
D E	*Brackets, Operating* F
F	*Bridge Alinement Circuit Closer*
G	*Circuit Closer on Wedges of Bridge*
L	*Electric Lock on Valve of Draw Mechanism.*
18-L, 20-R	*Bridge Signals*

Letters Refer to List of Names of Parts Below.

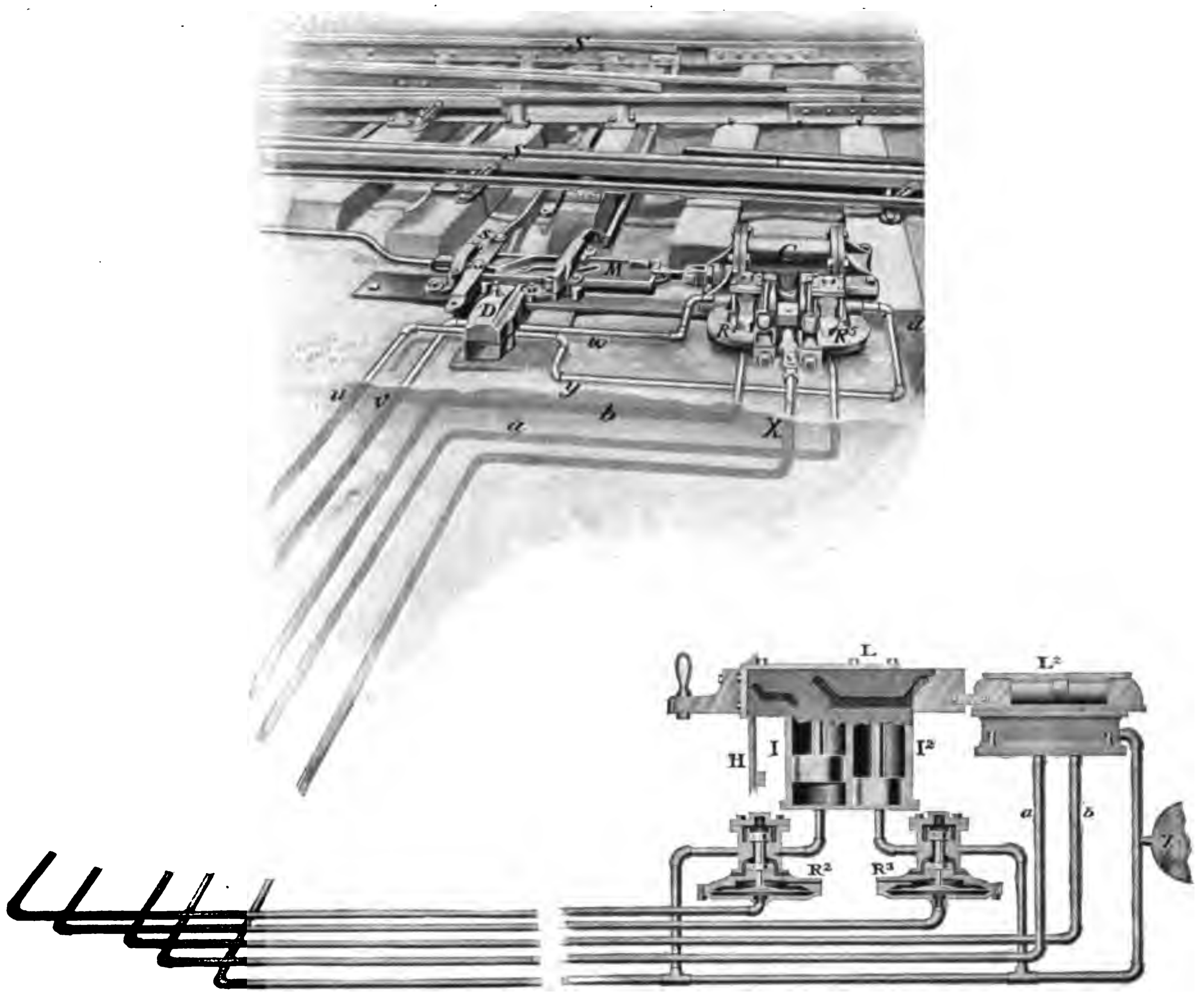


Fig. 1966. Low-Pressure Pneumatic Switch Movement and Lever Connections.

Names of Parts of Low Pressure Pneumatic Switch Control Mechanism; Fig. 1966.

C *Switch Cylinder*
D *Indicating Valve*
H *Tappet*
I *Normal Indication Cylinder*
I² *Reverse Indication Cylinder*
L *Lever*
L² *Slide Valve*
M *Motion Plae*
R² *Normal Indication Diaphragm Valve or "Relay"*
R³ *Reverse Indication Diaphragm Valve or "Relay"*
R⁴ *Normal Operating Diaphragm Valve or "Relay"*
R⁵ *Reverse Operating Diaphragm Valve or "Relay"*
S *Switch Rails*
X *Air Reservoir*
a *Reverse Control Pipe*
b *Normal Control Pipe*
d *Long Tie Supporting* **C**
s *Lock Rod*
s¹ *Throw Rod*
u *Normal Indication Pipe*
v *Reverse Indication Pipe*
w *Normal Indication Pipe Between Cylinder and Indicating Valve*
y *Reverse Indication Pipe Between Cylinder and Indicating Valve*

THE LOW-PRESSURE PNEUMATIC INTERLOCKING

Interlocking apparatus worked by compressed air at low pressure (15 lbs. per sq. in.) and with no electrical features, is made by the General Railway Signal Company, and is in use on a number of railroads. Compressed air in separate pipes is employed to control the admission of pressure to the switch and signal cylinders. Pressure is admitted to working cylinders by valves actuated by large rubber diaphragms, which are worked by air at 7 lbs. pressure. The lever of a switch cannot complete its stroke until the switch has actually moved home and conveyed an indication of the fact to the cabin. The interlocking is mechanical, the parts being made small. They are of the "Standard" type (Figs. 726-771). While the action of compressed air in pipes is not instantaneous, like an electric impulse, the movement of switches is effected quickly enough for all practical purposes; and at ordinary distances the movement of a signal is practically simultaneous with its lever.

The distinctive features of the low-pressure pneumatic interlocking machine are: (1) A row of slide valves (called levers) like that shown in outline at L and L², Figs. 1966 and 1969. (2) The mechanical interlocking frame, placed vertically on the front of the machine. The manner of connecting the lever with the interlocking is indicated by the position and arrangement of the tappet H in Fig. 1966. (3) The indicating cylinders and their relays on each lever, as shown in Figs. 1966 and 1969.

Application of air pressure is required in every case to accomplish any movement. To move a switch or signal from normal to reverse position and to receive a return indication at the machine, an air pressure must be applied at the lever. All signals

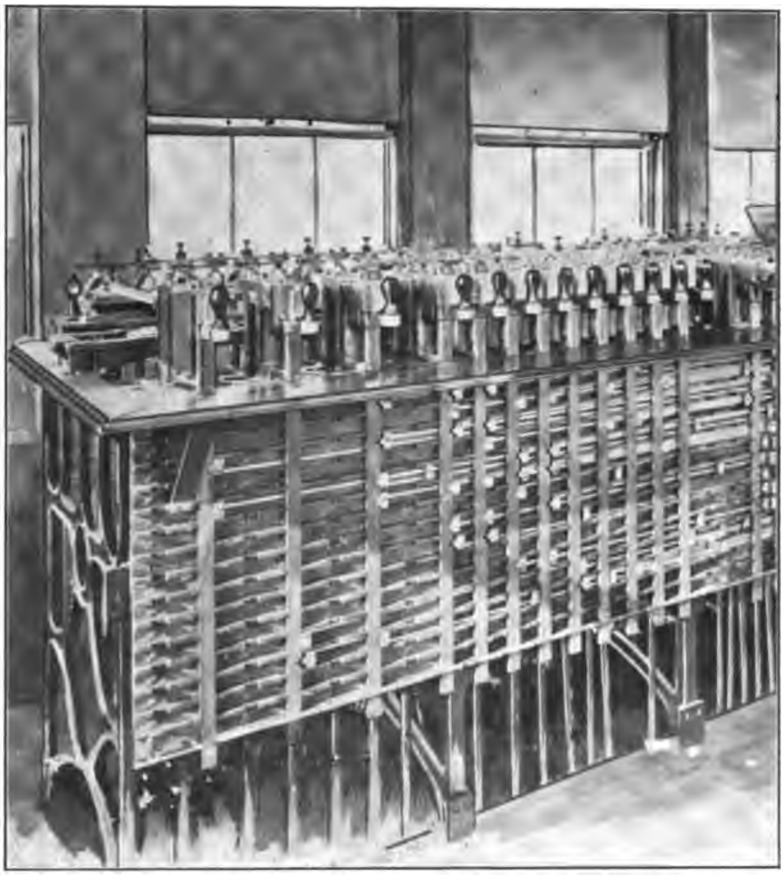


Fig. 1967. Low-Pressure Pneumatic Interlocking Machine.

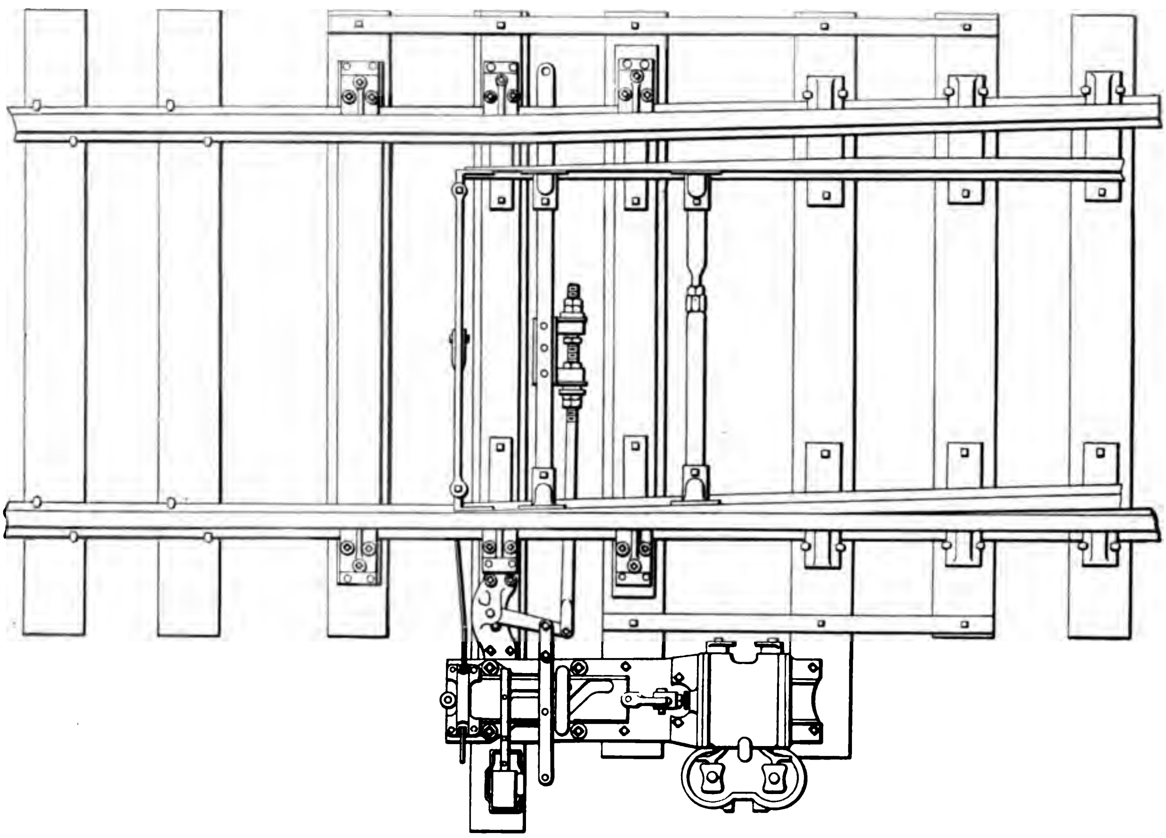


Fig. 1968. Low-Pressure Pneumatic Switch and Lock Movement with Gain-Stroke Lever. New York Central & Hudson River.

Letters Refer to List of Names of Parts Below.

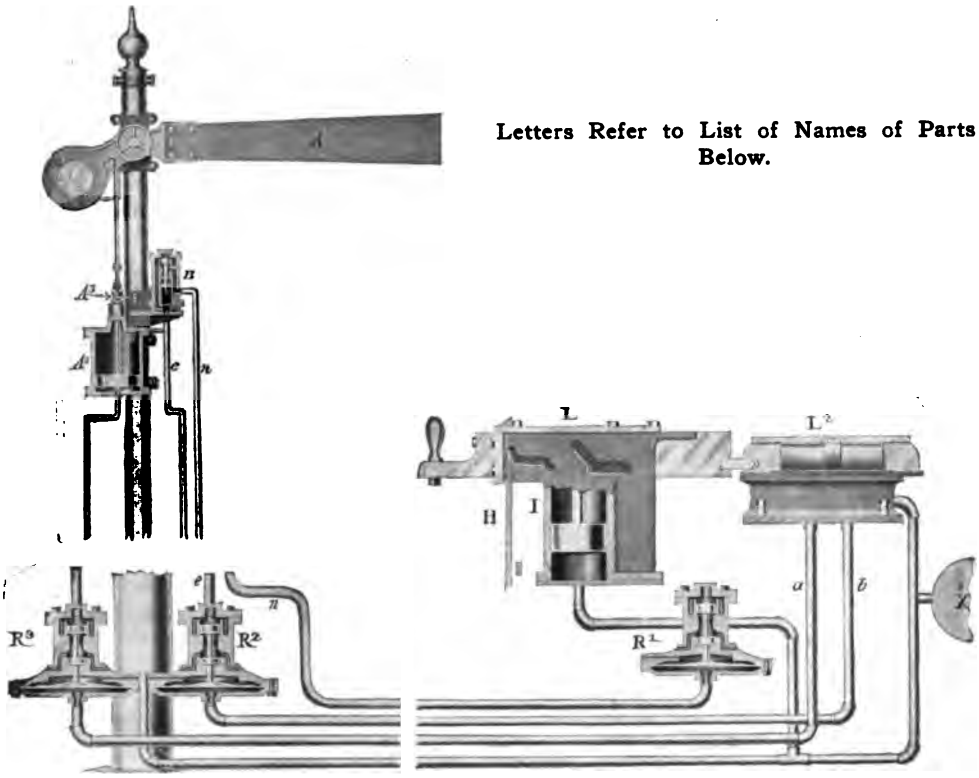


Fig. 1969. Low-Pressure Signal Movement.

Names of Parts of Low Pressure Pneumatic High Signal and Control Mechanism; Fig. 1969.

A	*Signal Arm*	R^1	*Reverse Indication Diaphragm Valve or "Relay"*
A^2	*Signal Cylinder*	R^2	*Normal Operating Diaphragm Valve or "Relay"*
A^3	*Indicating Valve Lever*	R^3	*Reverse Operating Diaphragm Valve or "Relay"*
B	*Indicating Valve*	X	*Air Reservoir*
H	*Tappet*	a	*Reverse Control Pipe*
I	*Indication Cylinder*	b	*Normal Control Pipe*
L	*Lever*	e	*Normal Control Pipe on Signal*
L^2	*Slide Valve*	n	*Indication Pipe*

are held in the proceed position by air pressure under the piston, the entire reverse operating line being charged from the tower to the signal when the signal lever is reversed. Thus absence or failure of power will always leave the signal in the stop position.

The appearance of the machine is shown in Fig. 1967, and the way in which the pressure is conveyed and controlled is shown in Figs. 1966 and 1969. Fig. 1966 represents the arrangement of valves and pipes forming the connection between the interlocking machine and a switch cylinder. The principal parts are: S, switch rails; s, lock rod; s^1, throw rod; M, motion plate; C, switch cylinder; D. indicating valve; R^2, R^3, R^4, R^5, controlling valves or relays; L, L^2, operating bar and slide valve on lever; I, I^2, indication cylinders; H, interlocking tappet; X, air reservoir.

To reverse the position of the switch the signalman pulls the lever L to the left. In doing this he admits air (from the main supply X through the valve L^2) through pipe *a* to valve R^5, which opens communication from the supply pipe X to the right-hand end of the cylinder C, pushing the piston to the left. Observing now the slots in L and M, it will be noted that after about one-half of the stroke L has been completed it is stopped by the piston rod of I^2; but the operation of valve R^5, already accomplished, causes M to move through the whole of its stroke. This stroke of M is uninterrupted, but it performs in succession three functions. The first part of the stroke, say one-third, does not move the switch, but valve D is moved far enough to close the two pipes on its right, while those on its left are open to the atmosphere. At the same time lock bar *s* has been liberated by withdrawal of a dog attached to M from notch in *s*. As M moves through the next or middle portion of its stroke, it moves the switch; but it now produces no effect on valve D, because the rod of D is now engaged by the straight portion of its slot in plate M. The switch being set, the third and final part of the stroke of M locks the switch by pushing a second dog attached to M through a second notch in *s*; and also (but not until after the dog has entered its notch) the plate changes valve D so as to connect together the two pipes *y* and *v*. This conveys pressure from the supply through R^5 and D to valve R^3, which valve then admits air from the supply to I^2, forcing the piston rod upward, and, by means of the diagonal portion of the slot in lever L, forcing it to complete its stroke. This return action takes place at ordinary distances in from one to three seconds. In rapid work, this automatic completion of the stroke of the lever saves an appreciable portion of the signalman's time. By the action of L^2 pipe *a* is now opened to the atmosphere, valve R^5 is released from pressure, and R^4 is closed; so that the right-hand pipe to cylinder C and its connection to and through D are open to the atmosphere. All four operating pipes are now at atmospheric pressure.

By the movement of L, tappet H has been moved so as to produce, in the first part of the stroke of L, the proper mechanical locking of conflicting levers, and in the last part of this stroke, the proper unlocking in the same manner and sequence that the same interlocking would have effected in a mechanical interlocking machine.

To move the switch back to its original position, the opposite set of pipes is used. The lever L is pushed to the right; air through *b* actuates R^4, and the return indication to the cabin actuates R^2 and lifts the piston in I.

A crossover switch or slip with movable point frogs is operated in the same manner excepting that the functions are connected in series, the air leaving valve D, going to the diaphragm operating the second function in the same manner as described for the operation of the first function. Pipes to any number of movements may be connected in series and operated from one lever in this manner, the indication from a preceding movement operating a following one, the last movement to operate giving the indication at the machine and automatically completeing the stroke of the lever.

To work a signal, valves and operating pipes are used of the same general style as those for a switch, but there is only one indicating valve and one indicating cylinder, as it is considered unnecessary to assure the attendant that a signal is in the proceed

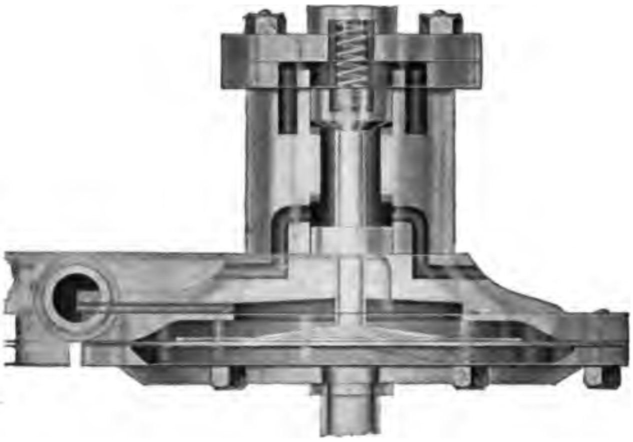


Fig. 1970. Pneumatic Diaphragm Valve or "Relay."

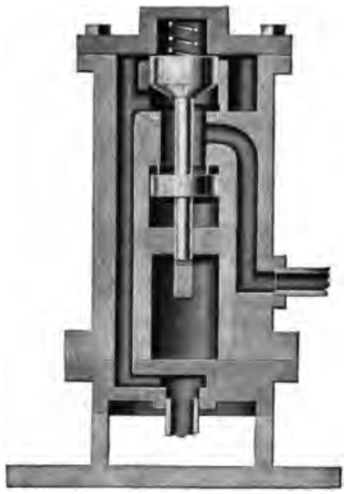
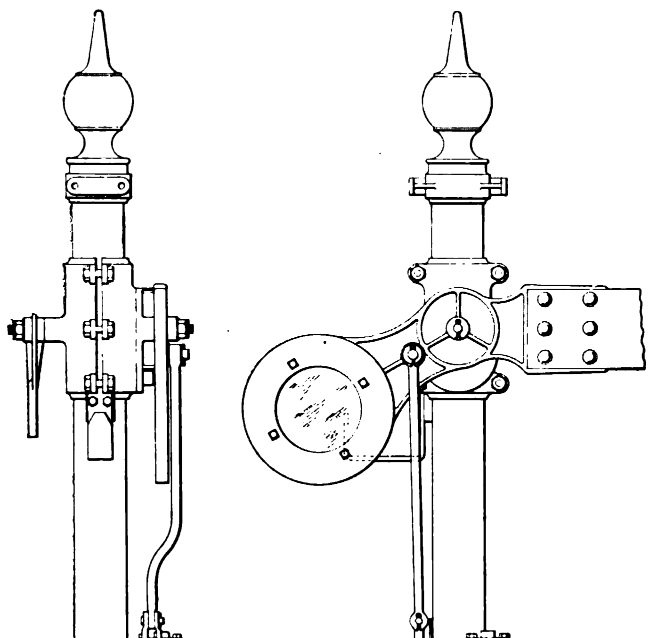


Fig. 1971. Indicating Valve for High Signal (B, Fig. 1969).

position. The signal connections are shown in Fig. 1969. The principal parts are: A', signal arm; A^2, signal cylinder; A^3, lever to work indicating valve; B, indicating valve; R^2 and R^3, diaphragm valves or relays, controlling the admission of air to the top and bottom, respectively, of the signal cylinder; R^1, diaphragm valve controlling admission of air to cylinder I. The signal being in the normal or stop position, the indicating valve B is in a position to maintain a connection between the two pipes attached to it; but as soon as the signal arm leaves the horizontal position the valve shuts off this connection.

To clear the signal the signalman pulls L to the left the whole length of its stroke. By this movement L^2, admitting air to pipe *a*, actuates valve R^3, which supplies air to the lower end of cylinder A^2 and pushes up the piston, putting the signal in the proceed position. The air impulse is transmitted so quickly that at the average distance (say 500 ft. or less) the movement of the signal is practically simultaneous with the movement of the lever. The signal remains in the proceed position as long as L is pulled to the left. To restore it to the normal or stop position, L is pushed to the right until it is stopped by the piston rod of I (at the end of the horizontal part of the slot in L). With L in this position, pipe *b* is charged and valve R^2 is opened. The passage between pipes *e* and *n* (through B) is now closed, so that the opening of R^2 admits air from the supply to the upper end of A^2. This restores the signal to the horizontal position, and by means of A^3 opens valve B. Air now passes from *e* through B and *n* to R^1, and the latter causes air to enter I and complete the return stroke of L by the action of the piston rod on the diagonal part of the slot. Pipes *b*, *e* and *n* are now at atmospheric pressure, and the parts are in the same position as at the beginning.

In Fig. 1970 is shown the diaphragm valve, which is called the "relay," its function being similar to that of an electro-magnetic relay in electrical apparatus. This valve is actuated by air at 7 lbs. pressure. This pressure, admitted beneath the circular rubber diaphragm 8 in. in diameter, pushes up the cylindrical valve, placed vertically in the upper part of the case, and thereby



Figs. 1972-1973. Pneumatic High Signal.

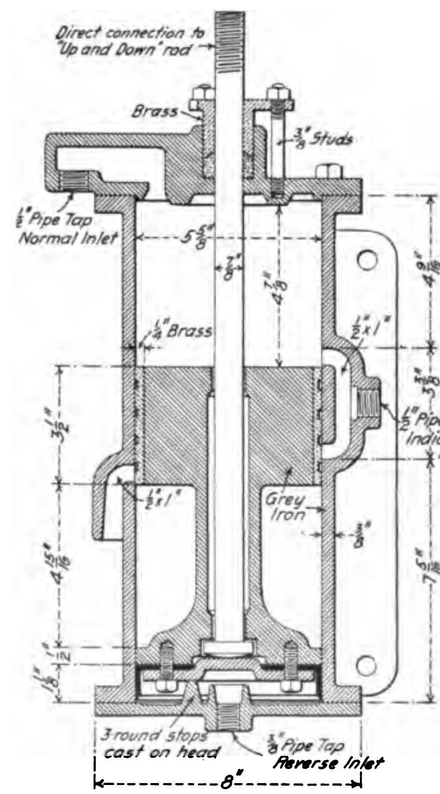


Fig. 1974. Improved Type of Cylinder for Pneumatic High Signal.

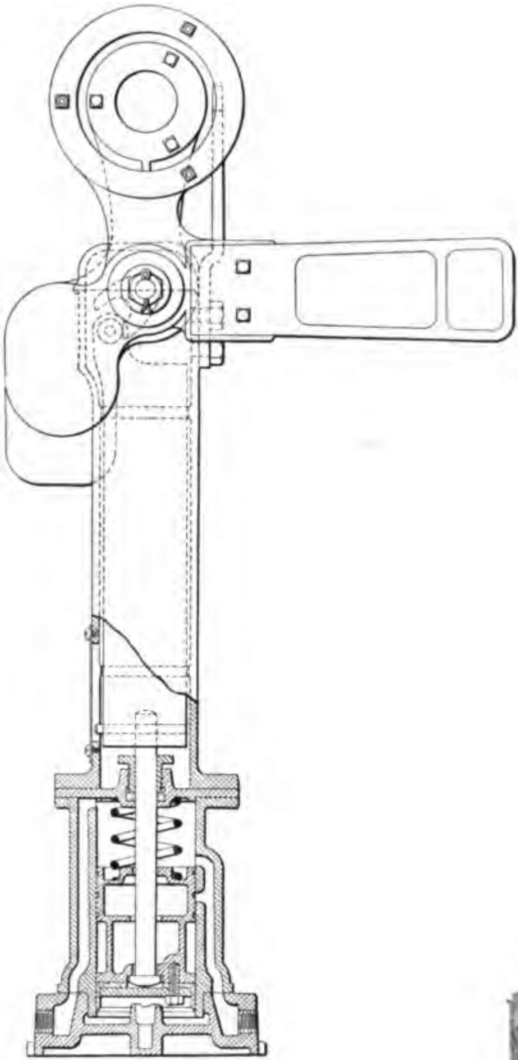


Fig. 1975.

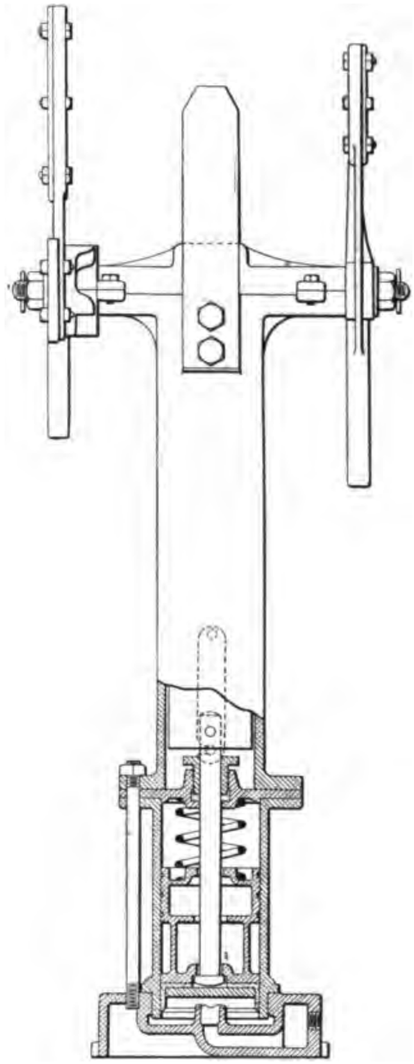


Fig. 1976.

Fig. 1977.

Figs. 1975-1977. Low-Pressure Pneumatic Dwarf Signal.

admits air at 15 lbs. per square inch to move the piston in the switch or signal cylinder. The movement of the diaphragm is only ¼ in.

The operating and indicating pipes extending to switches and signals are ½ in. in diameter. The supply pipes from the air reservoirs are larger, the size being varied according to the number of switches and signals to be operated. The air as it comes from the compressor is run through cooling pipes for the purpose of precipitating moisture.

Any number of signals controlling relative movements over the same switches may be connected up to one signal lever by placing selector valves at switch points to control the admission of air to the proper signal line. This method provides practically the same protection as bolt locking the switch points with signal lines at mechanical plants.

Fig. 1968 shows the method of providing a gain stroke lever from switch and lock movement to switch point, and also shows the general appearance of a switch connected up to the low pressure system, for either rear or advance bar movements.

The common type of semaphore movement used with the low pressure pneumatic system, is shown in Figs. 1972-1973; the movement is effected by the operation of the relays, controlled by the signal lever in the machine as explained in Fig. 1969. An improved semaphore movement known as style B is shown in Fig. 1974. The principles of operation are the same as described in connection with Fig. 1969, excepting that the indication is controlled by a piston so arranged as to pass the air from the normal side of the piston to the indication line when the signal arm has assumed the stop position.

Figs. 1975-1977 show a Style E, pneumatic dwarf signal. The operation is effected through the same control medium as shown in Fig. 1969, the indication, however, is controlled by a piston valve in the same manner as shown in Fig. 1974.

Fig. 1978. Motor Starting Signal, Used at Ends of Passing Sidings in Controlled Manual Block System. American Railway Signal Company.

Fig. 1979. Motor Dwarf Signal Mechanism and Case. American Railway Signal Company.

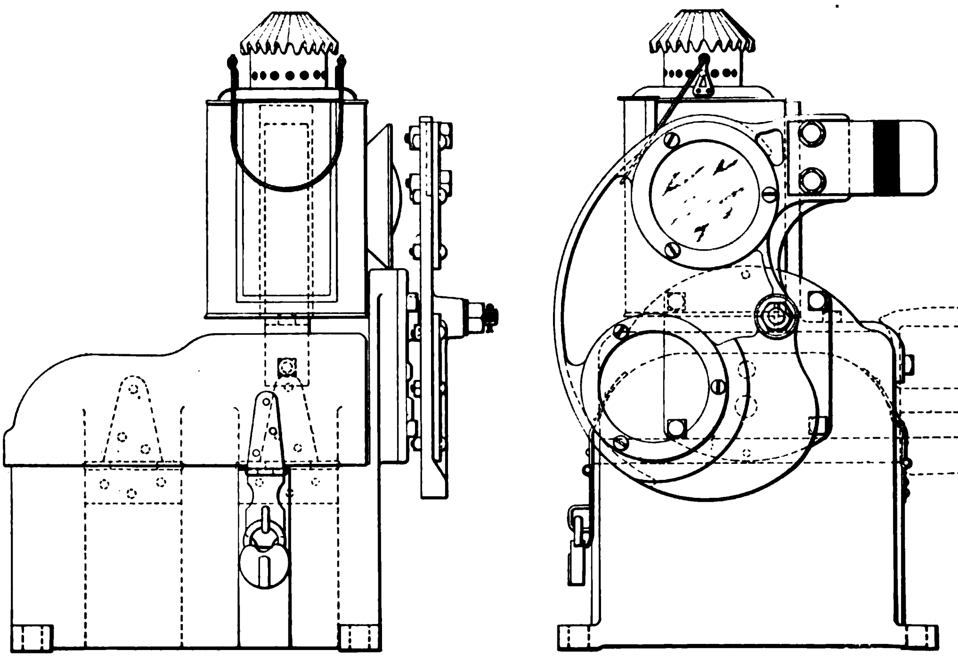
Fig. 1980. Motor Dwarf Signal. American Railway Signal Company.

POWER OPERATED SIGNALS AT MECHANICAL INTERLOCKING PLANTS

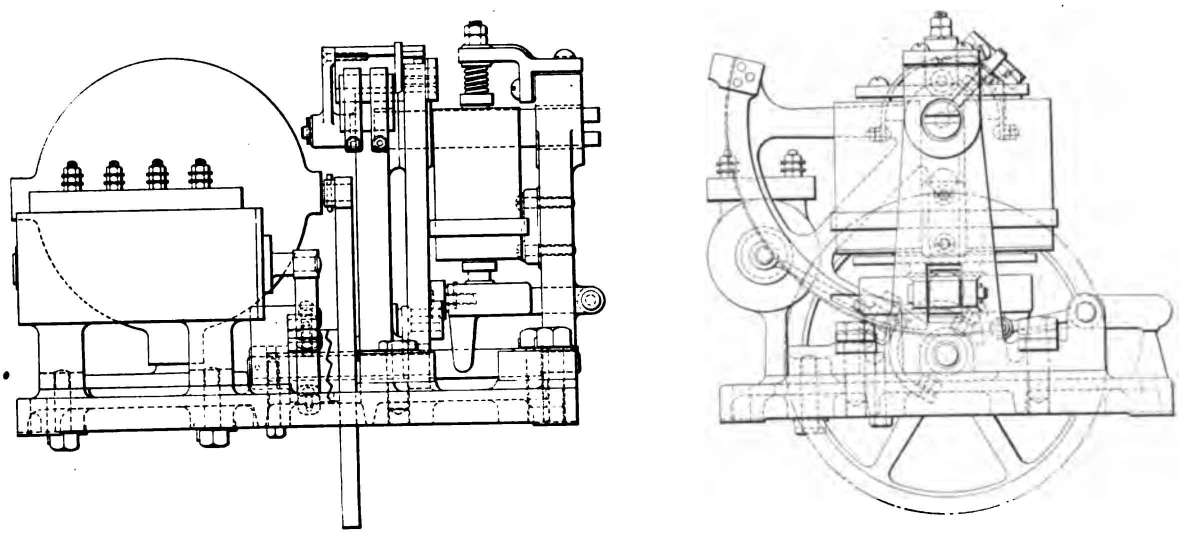
Where power operated semi-automatic signals are used at mechanical interlocking plants, provision is usually made to compel the signalman to put his signal lever normal after the passage of a train. Such signals, if of the automatic type, will clear as soon as the train leaves the block if the lever remains reversed, and permit another train to follow, which might result in delays. For this purpose, some form of "stick" relay wiring may be employed. Fig. 1989 shows circuits for this purpose. The circuit controllers shown are operated by the lever latch. The 500-ohm stick relay is kept energized under normal conditions by a circuit as follows: From the battery D, through wires 4, 6, circuit controller A, wires 9 and 12, coils of relay, wires 10 and 8, circuit controller C and wire 3 to battery. Current can also flow through wire 5, relay point, wires 11 and 12 and to battery through coils. Raising the latch opens circuit controller A. Lowering latch with lever reversed closes circuit controller B and opens C; C does not open, however, before B closes. Current now flows from battery through wires 4 and 5, relay point, wires 11 and 12, coils of relay, wires 10 and 7, circuit controller B, wire 2, track relay point, wire 13, signal mechanism, wire 1, to battery. This clears the signal. Passage of a train opens the track relay points, putting the signal to the stop position and opening the circuit of the 500-ohm stick relay. As the signal control circuit passes through the point of this relay, the signal cannot again clear, because this relay will not be energized again until the lever is latched in the normal position. In this case it is assumed that the coil through which this current passes at the signal is wound to 500 ohms; if that resistance is less the stick relay winding should be reduced accordingly.

Another circuit arrangement for accomplishing the same results is shown in Fig. 1990. The stick relay has two windings, one of which, D, is energized by the battery A through controller contacts F and E and wires 1, 2, 3 and 0. The circuit controller is of the snap type. Contact G must close just before the other two open when the lever latch is lowered with lever reversed; and E and F must close only when latch is lowered with lever normal. With lever reversed and latched, current flows from battery A, through wire 1, controller contact G, wire 4, coil C of stick relay, wire 5, contact on stick relay, wire 6, contact on track relay, wire 7, signal mechanism, and wire 0 back to battery. This keeps the stick relay energized and clears the signal. The presence of a train in the block opens the track relay and breaks the circuit for the signal and stick relay. This puts the signal to stop and opens the stick relay which cannot again pick up until the lever is latched normal.

Fig. 1991 is a diagram of circuits in use on the Erie Railroad



Figs. 1981-1982. Electric Dwarf Signal (See Figs. 1979-1980). American Railway Signal Company.



Figs. 1983-1984. Electric Dwarf Signal Mechanism (See Figs. 1979-1982). American Railway Signal Company.

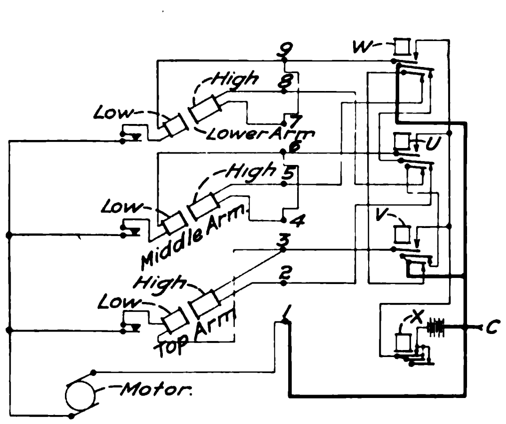


Fig. 1985. Diagram of Control Circuits for Three-Arm Style "B" Union Semaphore Distant Signal at Mechanical Interlocking Plant. Pennsylvania Railroad.

NOTE.—1, 2, 3, 4, 5, 6, 7, 8, 9, binding posts; U, V, W, control relays; X, track relay. (See Figs. 2001-2003.)

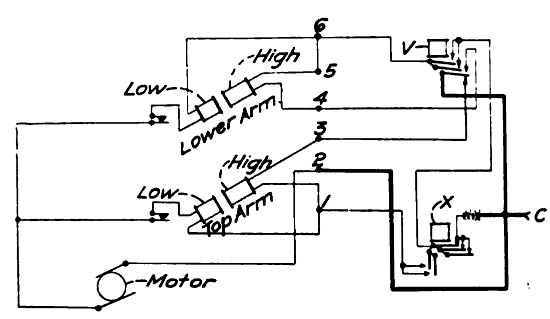
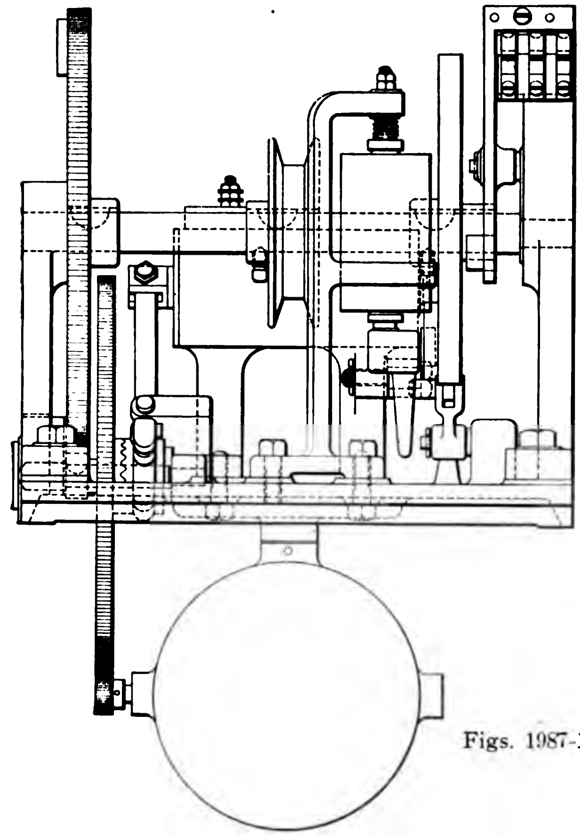
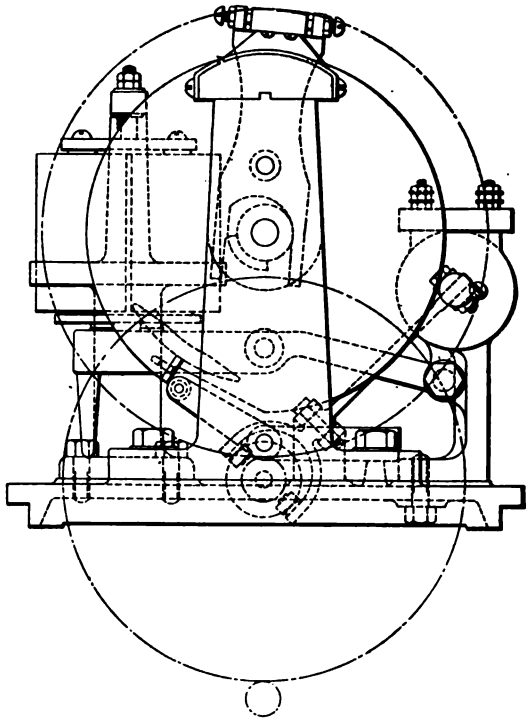


Fig. 1986. Diagram of Control Circuits for Two-Arm Style "B" Union Semaphore Distant Signal at Mechanical Interlocking Plant. Pennsylvania Railroad.

NOTE.—1, 2, 3, 4, 5, 6, binding posts; V, control relay for lower arm; X, track relay. Top arm is controlled by polarity of track circuit. (See Figs. 2001-2003.)





Figs. 1987-1988. Mechanism for Starting Signal (Fig. 1978).
American Railway Signal Company.

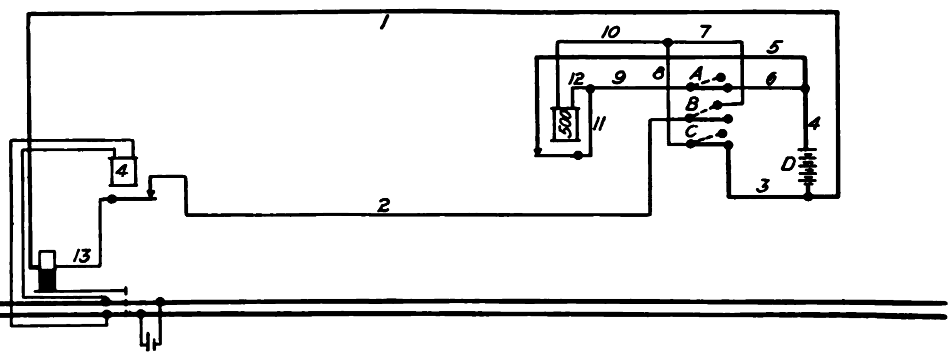


Fig. 1989. Circuit for Power Operated Signal at Mechanical Interlocking Plant.

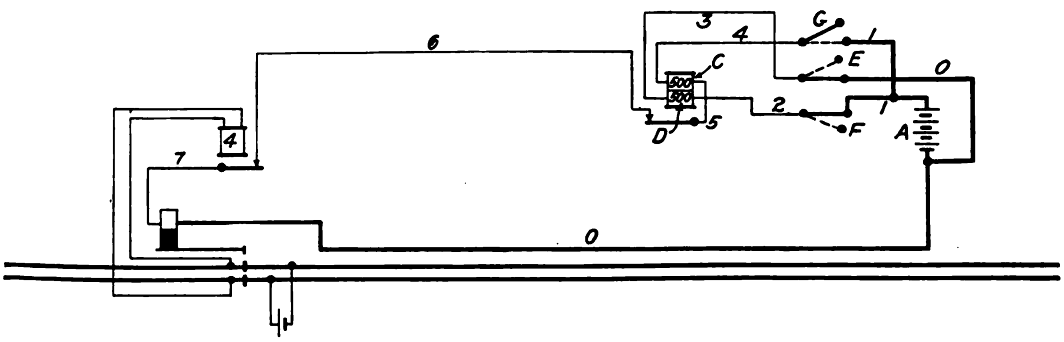


Fig. 1990. Circuit for Power Operated Signal at a Mechanical Interlocking Plant.

for electrically operated distant and advance signals, with electric switch locks for outlying switches at an interlocking plant. Circuits east and westbound are similar and have similar numbers. The circuit for distant signal 1 is as follows: From the battery at the tower, through back contact on indicator I, circuit controller P (on lever 1), wire 1, circuit controller V (on signal 3), relay D at signal 1, to common wire 6, back to battery. Indicator I is operated by circuit from battery H at signal 2, through circuit controller G', wire 4' and hand switch L. Therefore, to clear signal 1, advance signal 2 must be cleared (closing the contact on I) and also the home signal 3.

Advance signal 2 is controlled by a circuit from the main battery through circuit controller S (on lever 2), wire 5', relay D (at signal 2), circuit controller B' (on electric switch lock A'), to common wire 6'. If the lock A' has been released to open the switch, B' will prevent signal 2 from clearing.

The switch lock A' is controlled by the hand switch L, using the same circuit from battery H at signal 2, that operates indicator I. When L is reversed this current passes through wire 3', switch lock A', wire 5' back to battery. When L is reversed indicator I is energized by the tower battery, thereby keeping the circuit for distant signal 1 open. Locks N and O act on the home-signal levers to lock the latches while the distant signal is clear, so that the lever may be put normal, but not latched in that position. The telephones U are installed in the tower and at the outlying switches. Trainmen use these to request an unlock from the signalman when they wish to use the switch. The telephone circuit is carried on the main common on one side, and the ground, through condensers, C, on the other.

Letters Refer to List of Names of Parts Below.

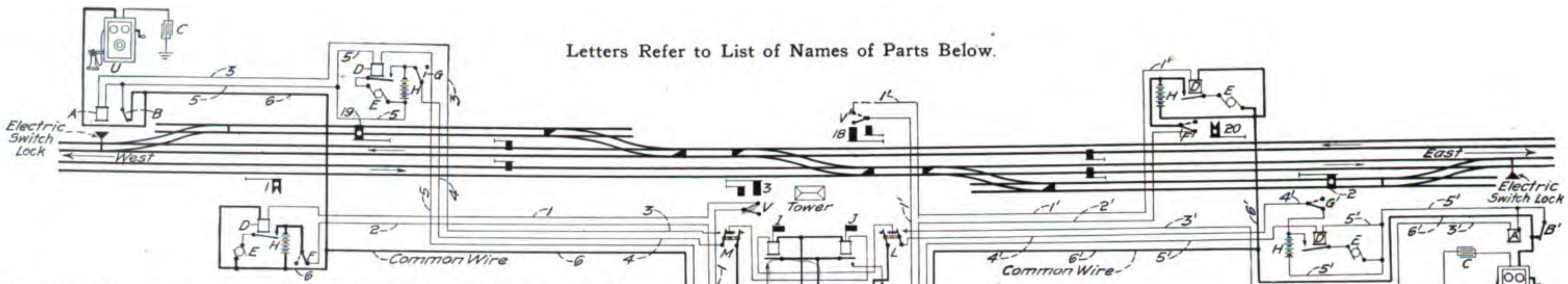
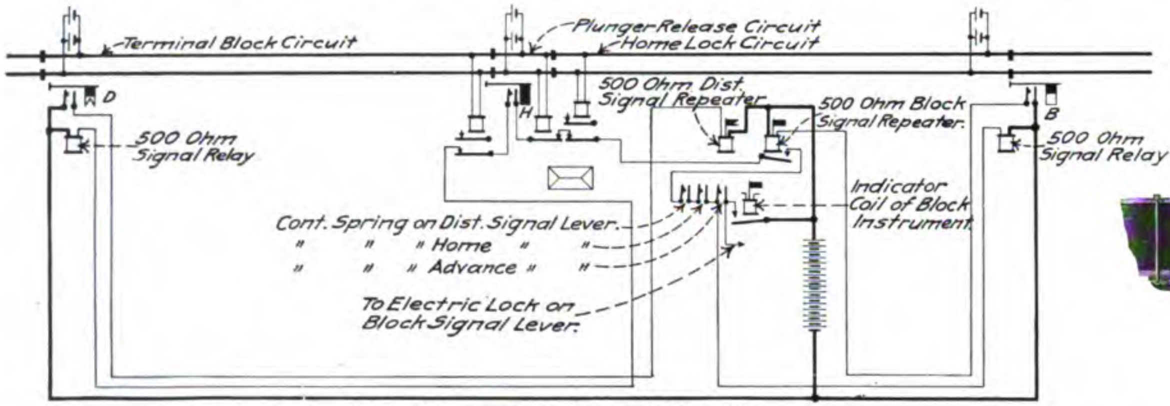
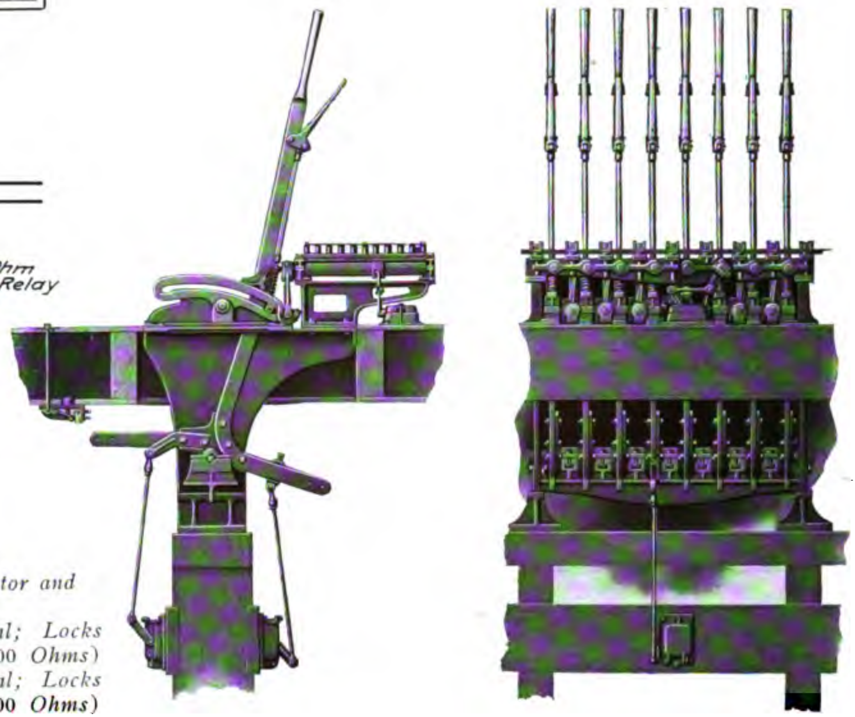


Fig. 1991. Circuits for Power Operated Signals and Outlying Switch Locks at Mechanical Interlocking Plant. Erie Railroad.

Fig. 1992. Circuits for Power Operated Distant and Advance Signal at Controlled Manual Block Station. (See Figs. 251-262.) New York Central & Hudson River.





Figs. 1993-1994. Saxby & Farmer Interlocking Machine Showing Various Methods of Applying Horizontal Rotary Circuit Controllers. The Union Switch & Signal Company.

List of Names of Parts of Fig. 1991.

A *Electric Switch Locks*
B *Circuit Controller on Electric Switch Locks*
C *Condensers for Telephone Circuits*
D *500 Ohm Relays*
E *Signal Motors*
F *Circuit Controller on Distant Signals*
G *Circuit Controller on Advance Signals*
H *16 Cells, Primary Battery*
I *East Bound Indicator (1000 Ohms)*
J *West Bound Indicator (1000 Ohms)*
L *Switch for Controlling East Bound Indicator and Electric Switch Locks*
M *Switch for Controlling West Bound Indicator and Electric Switch Locks*
N *Lever Lock on East Bound Home Signal; Locks Latch Up When Lever is Normal (1000 Ohms)*
O *Lever Lock on West Bound Home Signal; Locks Latch Up When Lever is Normal (1000 Ohms)*
P *Circuit Controller on East Bound Distant Signal Lever*
Q *Circuit Controller on West Bound Distant Signal Lever*
R *Circuit Controller on West Bound Advance Signal Lever*
S *Circuit Controller on East Bound Advance Signal Lever*
U *Magneto Telephone*
V *Circuit Controllers on Home Signals*

ELECTRIC LOCKING

In a mechanical interlocking plant there are detector bars to prevent switches being thrown while a train is upon them, and they have been a safety device of great value. But the only check on the manner in which the signalman handles his levers at such a plant is the dog locking and the detector bars, and with moderate speed of trains and a high intelligence in signalmen nothing more could be desired. But speeds have been increased to such an extent that distant signal indications must be given farther away, and power has been introduced to work switches and signals.

Increased speed means more space to stop in, and with the simple mechanical plant there is nothing to prevent a signalman from changing the route after a train has passed the distant signal at clear; this might lead to running a train off a derail or through a sharp turnout at high speed, with disastrous results. Power used to operate switches has frequently crumpled up detector bars under trains. With rail larger than the 85-lb. section the ordinary outside detector bar cannot be counted upon to strike the tread of the wheel, and inside detector bars (Figs. 911 and 1000-1002) for various reasons are not considered desirable. Thus a switch or derail may, under certain conditions, be thrown under a moving train. Furthermore, detector bars as usually installed, are operated on a false principle; if they fail, they are inoperative. To overcome these and other difficulties, electric locking has been introduced. It may be considered an extension of the functions of the track circuit, and, in some methods of application is called track circuit locking.

As applied to mechanical interlocking it is usually quite simple. It involves only the use of electric locks (Figs. 2318-2337) on the latches of certain levers, usually those of the home signals; although if the protection is to be made more complete, they are applied to certain special route levers or to regular levers that can be used as route levers.

These locks are controlled by circuits passing through the contact points of track relays in the various sections involved. This control is usually accomplished through the medium of an indicator (Fig. 2034, etc.); that is, the track relays control the indicator, and the indicator controls the lock.

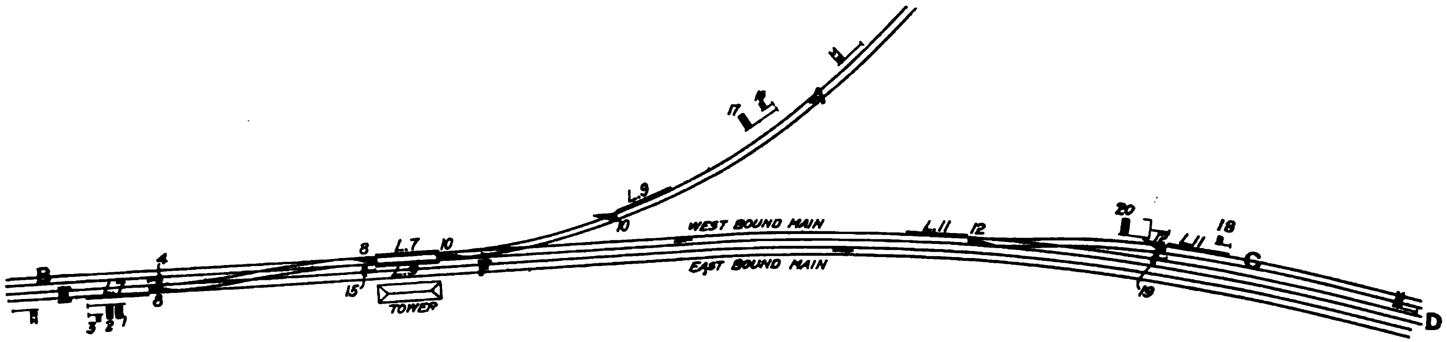


Fig. 1995. Interlocking Plan, Single and Double Track Junction.

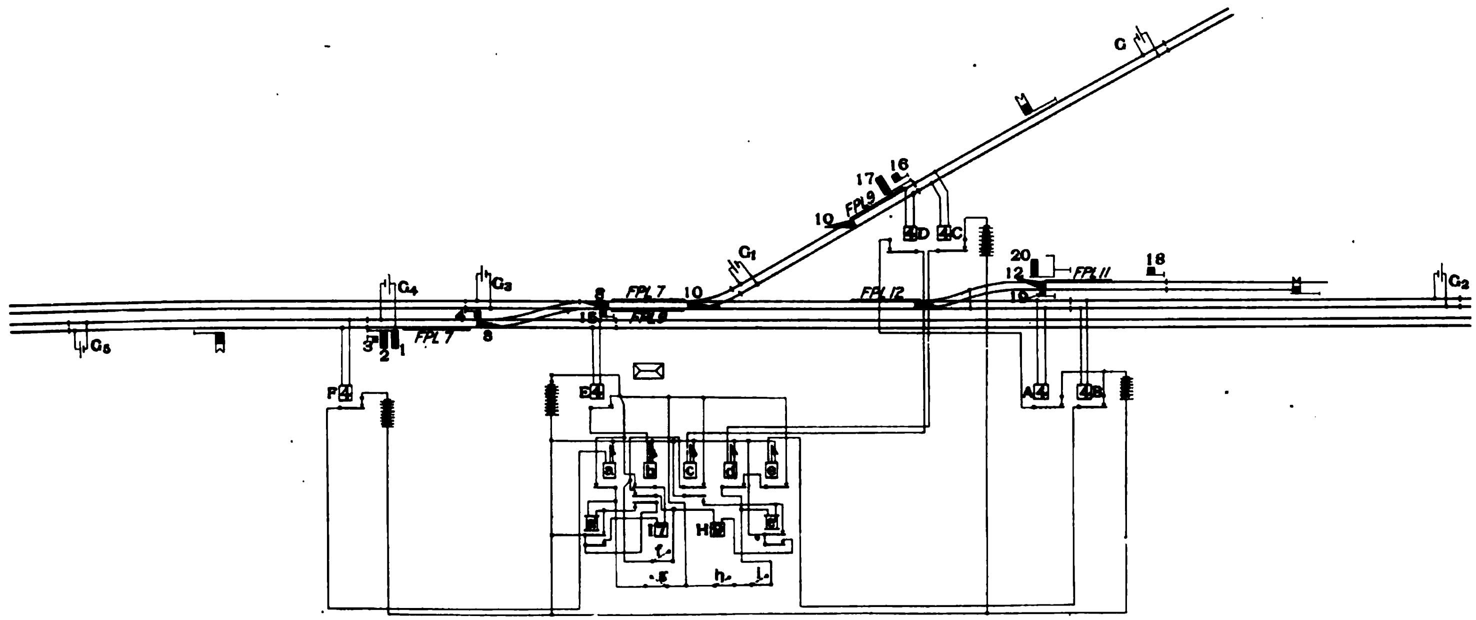


Fig. 1996. Electric Locking for Switches and Signals Shown in Fig. 1995.

This is done in order to give a visual indication of the condition of the track section and not compel the signalman to depend upon watching the train or trying his levers. Repeated trials will in time wear out the dog and the slot of the lock. The relative protection afforded by locking signal levers and route levers respectively, may be understood by reference to Fig. 1995, which shows the layout of an interlocking plant having a twenty-lever machine. If the latches of high home signals only are controlled by track circuits, protection will be given only to trains moving in the established direction of traffic on the high-speed routes. For example, suppose that the switches are set up for the route from A to B, signal 17 cleared, and a train is on some part of this route. Then the latch on lever 17 is locked so that it cannot be lowered in the normal position (and in consequence of this no locking will be released) until the train has passed signal 4; 17 reversed locks 9 reversed, which locks 10 reversed; also 17 reversed locks 7 reversed, which locks 8 normal; also 4, 20 and 18 are locked normal; therefore, it is safe for the train to proceed, as none of these functions can be moved. But suppose that the signals are set for a movement from B to A; now 4 reversed will lock all the conflicting and opposing functions, but it has no lock on its latch, and therefore no track circuit protection. This could be overcome by putting locks on all the dwarf signal latches, but this is considered too expensive. Also if the signal were out of

service and the signalman should flag a train through without reversing his signal lever, there would be no protection.

Full protection can be provided at minimum expense by choosing certain levers as route levers and locking their latches. There are the following possible routes in the present case: A-B, C-B, D-B, A-E, C-E, D-E, E-F, B-A, B-C, B-D, E-A, E-C, E-D, F-E. These routes may be so grouped together that from A to all possible points can be considered as one route; the same for B and E. Now, if the dog locking is arranged so that in setting up a route to or from A or B, 9 must be thrown last before the signal, and to or from E, 7 must be thrown last before the signal, then 9 or 7 reversed will lock all the functions in the route and will in turn be locked by the signal lever. Therefore, levers 9 and 7 are the only ones whose latches need be supplied with locks. These locks must lock the latch down with the lever reversed. This must be done every time a derail or lock lever is used as a route lever. Frequently when a switch lever is used as a route lever the lock must lock the latch down with the lever either normal or reversed. When so supplied protection against improper movements of switches and derails is afforded without reference to the home signal levers, no matter what route is being used. Whenever a lock is placed on a signal lever it should never hinder moving the lever far enough to cause the signal to assume the stop position (or caution position in case of a distant signal), because it should always be possible to move the lever to stop a train in case of emergency.

Another method is to have the home signals locked as soon as cleared, and released only when a train has reached a certain point within or beyond the interlocking limits. This will be discussed later in connection with approach locking.

At power plants with electric control the same methods as above described may be used; that is, electric locks on the levers may be used. Usually there are no latches or latch locking at these plants, consequently the lever itself must be locked. Another difference is that there are usually no separately operated facing point locks at power plants; therefore a derail or switch lever must be used for the route lever, and be controlled by the electric locking. If signal levers are to be locked it is often convenient to break their indication circuits through relay or indicator contacts, thus avoiding the necessity of an additional electric lock. Also with the same effect, the control circuits of switches and derails are broken through such contacts.

If the indication circuit of all signals concerned are broken while a train is occupying the route or section of route governed, the protection will be complete. For, when the indication circuit is broken, the releasing device on the lever cannot act, and the lever is held in an intermediate position, thus locking all opposing and conflicting routes as if it were at full reverse. Usually, however, the indication circuits of the high home signals only and the control circuits of the switches and derails in a route are broken. This is done, because if, with no means of holding the

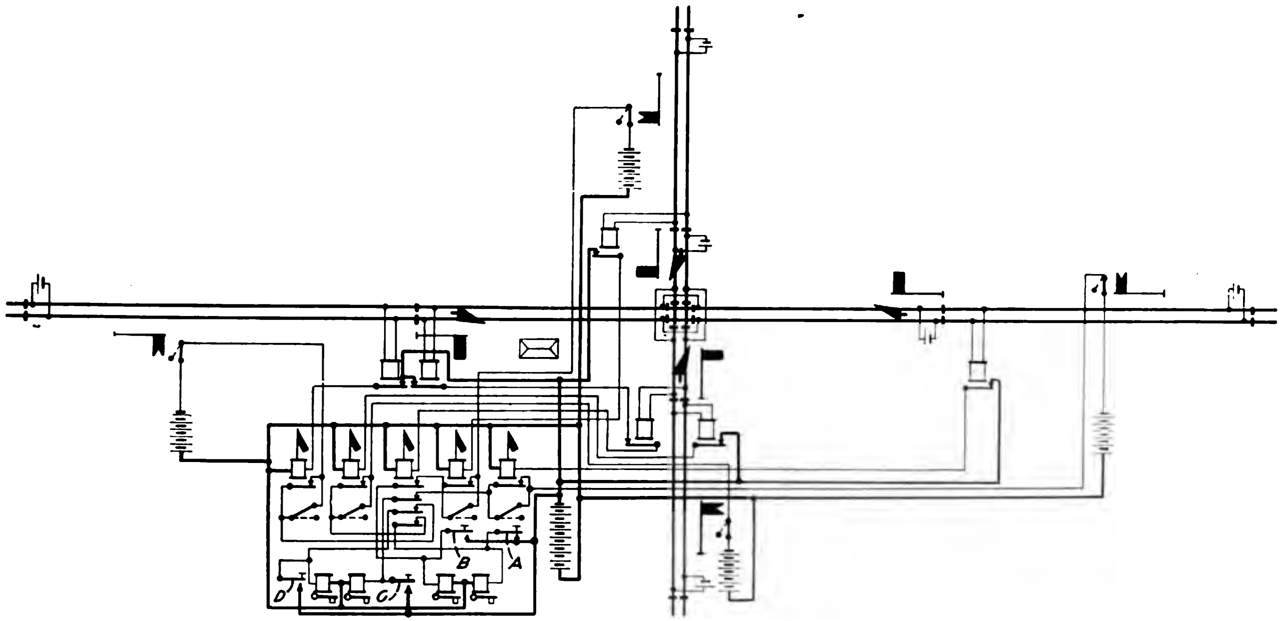


Fig. 1997. Electric Locking Circuits for Single Track Crossing.

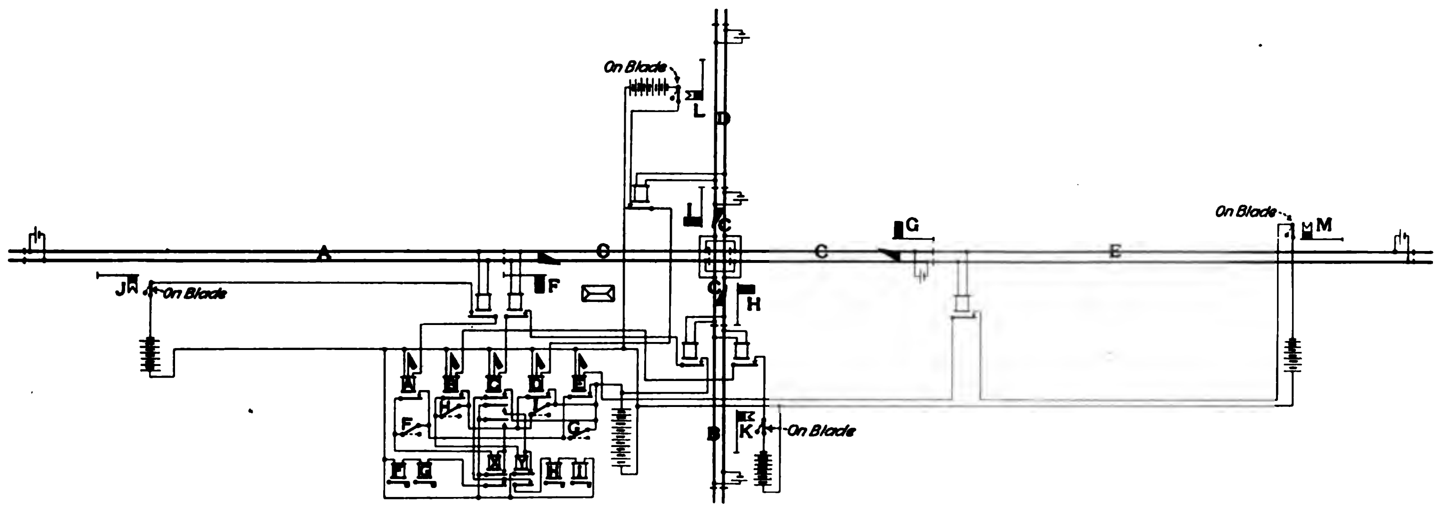


Fig. 1998. Electric Locking Circuits for Single Track Crossing.

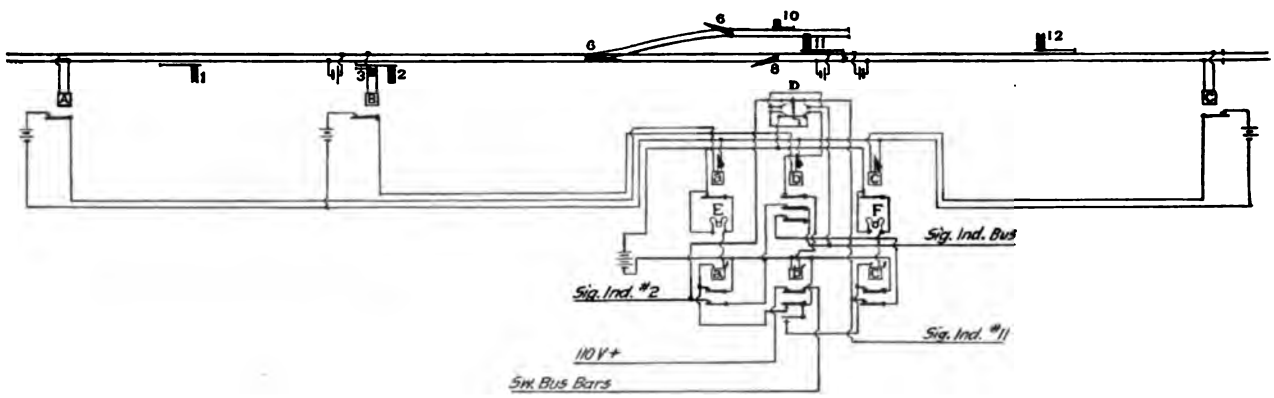


Fig. 1999. Approach Locking for Single Switch on a Single Track Main Line.

switches, a signal should be out of order, and it were necessary to flag a train through, there would be no protection; this for the reason that there would be nothing to compel the signalman to reverse his signal lever, and with the signal lever normal the route would not be locked. The best system would seem to be a combination of lever locking and circuit control; that is, to break the high home signal indication circuits and the switch and derail control circuits and lock route levers.

In another system of electric locking, conflicting routes only are locked; that is to say, a train in a certain route locks switches and derails in conflicting routes only. This is no more than dog locking is designed to do, except that it holds after the signal lever has been put normal, until the route is clear.

At power plants controlled otherwise than electrically, lever locking is the only kind that can be economically and efficiently applied. Valves and their controlling apparatus are cumbersome and expensive.

Where any one of these systems is applied only to track sections within the home-signal limits the use of detector bars can hardly be dispensed with. It takes an appreciable length of time for a track relay to act, and the indicator and lock consecutively consume equal periods. Therefore, before the lock has acted it may be possible to change at least one of the switches or derails in the route. Consequently, it is advisable to have a detector bar at the entrance to each high-speed route, at least.

To overcome this difficulty and to better prevent any change of route after a train has passed the distant signal at clear, approach locking has been introduced. This is an arrangement of circuits whereby the lock on the home signal or route lever latch, operates when a train approaches the interlocking plant with the governing signals in a certain position.

Broadly, there are in use two systems: In one the lock acts as above when the train is approaching the distant signal with the home signal clear, and holds until the train has reached a point within or beyond the interlocking limits. This may be modified so as to require the distant signals, also to be clear; or it may be made to act when a train has passed the distant signal with the home signal clear. In the other system, the route is locked as soon as the home signal is cleared, regardless of whether a train is approaching or not. Of course, in dealing with electrically controlled power plants the above may be modified so as to break control and indication circuits as already described.

Fig. 1996 shows the approach and other locking circuits for the mechanical interlocking plant shown in Fig. 1995. The system is that described for Fig. 1995, using 7 and 9 as route levers, and the first of the approach locking systems.

A, B, C, D, E and F are track relays operated by batteries G, G_1, etc., through their respective track sections; a, b, c, d and e are indicators; a is controlled by F, b by E, c by A and D, d by C and e by B. H is a lock on the latch of lever 9, and I is a lock on latch of lever 7; f, g, h and i are circuit controllers operated by levers 8, 2, 17 and 20, respectively. Suppose a train to be approaching on the branch line with the route lined up. Until the first track battery G is passed the route can be changed at will, but as soon as G is passed relay C opens, thereby de-energizing indicator d, relay e′ and lock H. For, when No. 17 was reversed circuit controller h was opened and the shunt on the point of d and e removed. Thus lever 9 is locked reversed and the route cannot be changed. Lever 9 remains locked until the train has passed beyond signal 4, as by its passage relays D and A are successively opened, thereby de-energizing indicator c. This keeps the circuit for lock H open. The signalman is prevented from restoring his lock (by putting his signal levers normal) while a train is approaching by the special stick wiring of the relays a′ and e′ which control the locks with the "home" indicators b and c. They are controlled by the approach indicators a, d and e, and break their own circuits. They can be restored only through the back contacts on their respective home indicators when a train is in the home section. Suppose the train approaches without the signals clear; in this case the route would not be locked and the signalman could hold the train at the home signal until ready for it to proceed. At the same time he could allow another train to use any of the routes within the plant. The purpose of circuit controller f on lever 8 is this: Suppose that the route through the crossover reversed is set up for an eastbound movement. Now, to be safe, lever 9 must be controlled by relay E (through indicator b); otherwise it would be possible to move any of the switches except the crossover, until the train had passed through the crossover onto the track circuit controlling relay A. Therefore f is made to break the shunt around the contact point of indicator b in the circuit of lock H. Lock H cannot be controlled by this indicator in all cases, because if this were done a train on the eastbound track would prevent changing a route on the westbound track, when it would be proper to do so.

One modification that is frequently made is to put the circuit controllers on the distant signal levers. When this is done the approach locking takes effect only when the distant signal is clear with a train approaching. In the plant under consideration the distant signals are assumed to be power operated without separate levers. Sometimes the circuits for the approach indicators are broken through normally closed circuit controllers on the home and distant signal arms, so that if either should fail to assume the full stop position when the levers are put normal, the route would remain locked.

Fig. 1997 shows the circuits for approach and other locking at a single track crossing. Here a separate circuit is run for each

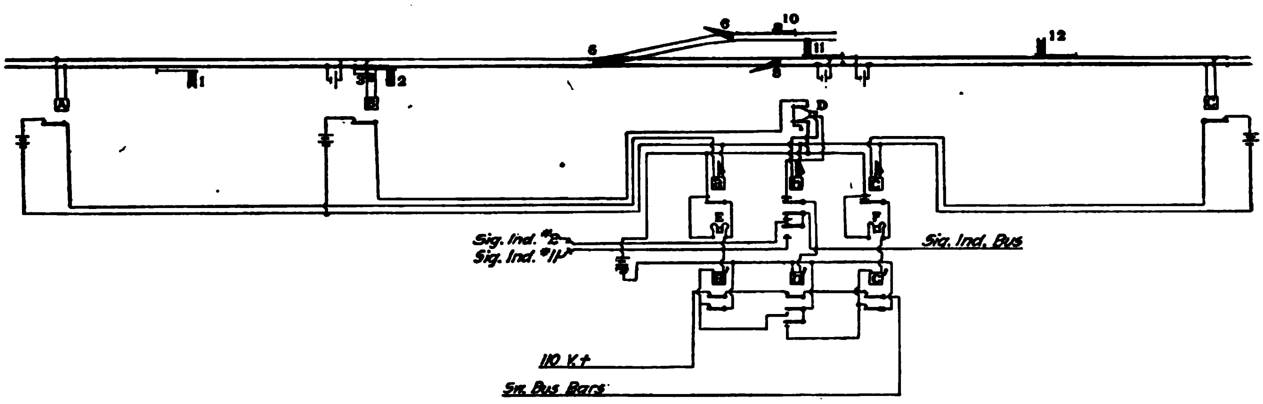


Fig. 2000. Approach Locking for Single Switch on a Single Track Main Line.

lock through circuit-breakers on the distant signals, so that the locking will not release until the distant signal arm is in full horizontal position. The locks act on the latches of the home signal levers to which are also attached the shunt circuit controllers (shown just beneath the indicators). These circuit controllers are closed only when the levers are normal and the latches down. The contacts A, B, C and D represent hand releases (usually some form of time-release, Figs. 2893-2908) which are used when it is necessary to change a route that has been given to a train.

Fig. 1998 shows the same crossing wired with the indicator circuit through a circuit controller on the distant signal arm. Here the approach indicator contact opens when the distant signal is cleared, whether a train is approaching or not. The locks act as in Fig. 1997, but the circuit controllers F, G, H and I need not be attached to the latches. They can work with the home signal levers. The stick relays, X, Y, hold the lock circuits open during the passage of a train, whether the signal levers are restored or not. These circuits are suitable for a power plant in which control and indication circuits are broken, and there are no locks on the levers. At such a plant stick relays are necessary (as there is no latch locking), unless the section of lever stroke, after indication has been received, is long enough to operate a circuit controller. At a plant where the home signal lever latches are locked stick relays are not needed, as the shunt circuit controller can be made to be closed only when the lever is normal with the latch down, as in Fig. 1997, and this condition will not occur until the lock is released. At power plants the point at which the lever is held for indication can sometimes be used as the latching point, as above. But in any case where the shunt circuit controller is operated by a lever other than the one upon which the lock acts, a stick relay must be used.

In a power plant using the first modification described for Fig. 1996, but without lever locks, indicators are provided, controlled by track circuits in the usual manner, as shown in Fig. 1999. In this diagram A, B and C are track relays; a, b and c indicators, a′ and c′ stick relays, b′ a secondary relay controlled by indicator b, and E and F, contacts on distant signal levers 1 and 12 respectively. The approach locking is accomplished by breaking the indication circuit of the home signal governing the route, through the front point of the stick relay, controlled by the circuit controller on the distant signal lever in parallel with a front point on the approach indicator. In this system, unless the distant signal has been cleared, it is possible to put a home signal lever normal at any time, provided a train is not in the section governed. This does away with delay in case the wrong route has been lined up. The stick relay is restored by a back contact on relay b′. With this system there is no delay due to the locking in case the signalman neglects to put his home signal lever normal promptly behind each train. When the distant signal is cleared with a train approaching, the home signal indication is withheld until the train has passed out of the home section. The current supply to the switch bus bar is cut through a contact on relay b′ in order to provide detector locking for a movement from signal 10. With this system signals can be tested at any time without necessitating the use of the hand release.

The second system, wherein the home signal is locked as soon as its lever is reversed, is used more extensively at power plants electrically controlled (see Fig. 2016). In this system the indication circuits of the home signals are normally broken through open back points of indicators, controlled by the home track circuits, so that the stroke of the signal lever to normal cannot be completed without using a hand release unless a train occupies the track section. In other words, if the signalman clears a home signal, he cannot completely restore his lever in the usual way unless a train is within the interlocking limits on the track governed. Additional approach locking is accomplished by breaking the power circuits of the switches and derails in the route governed through points on stick relays, as shown in Fig. 2000. In this figure indicators a, b and c are controlled by track relays A, B and C, respectively, a′ and c′ are stick relays, b′ is a secondary relay controlled by indicator b, and E and F are circuit controllers on the distant signal levers. The stick relays are controlled by the circuit controllers on the distant signal levers, in parallel with the front points of indicators, a and c, which are in turn controlled by the approach track circuits. The stick relays are restored by back contacts on relay b. The current supply to the switch bus bar is controlled by all three relays, a′, b′ and c′, providing electric detection. Hand releases D are provided in Figs. 1999-2000 for use, as explained in connection with Fig. 1997 and 2016. To compel the signalman to restore the release to its normal position after reversing it, the return for relay b′ is in each case cut through a normal contact on the hand release.

Some disadvantages of locking the route by reversing the signal levers, regardless of whether or not a train is approaching, are as follows; 1. It is impossible to test signals easily. Every time the lever is reversed it locks itself. This is particularly annoying at mechanical plants in winter, when it is necessary to move the signals frequently to keep them from freezing. 2. It interferes with the flexibility of operation. If the wrong route is lined up by mistake, it locks itself, thereby causing delay.

It will be observed that circuits for the control of routes are so arranged that if any part of the apparatus should fail or become deranged, the locking would act and hold the route, or possibly the whole plant, locked until the trouble is repaired. This is the governing principle in signaling. If anything fails, a dangerous condition must not result.

Figs. 2001-2003 show electric locking at Denholm, on the Pennsylvania Railroad. This is a mechanical interlocking plant. The locking circuits for the route governed by Signal 47 may be considered as typical. Circuit for lock 47: From battery at distant signal through circuit breakers on signal arms, wire 46K-47K1, front point of relay A4, wires 47K3 and 47K4, from point of indicator 4P wires 47K5 and 47K, circuit breaker on tappet, through lock to common. A branch 47K7, is taken off wire 47K3, through slow release to wire 47K, thereby cutting out the contact on indicator 4P with instruments in normal position. Another branch is taken off wire 47K3 to back point of relay B4, wire 47K6, to wire 47K. This also cuts out the front contact of indicator 4P when relay B4 is de-energized. The lock is de-energized with train in approach, distant or home track section, also with the distant signal clear and is not again energized until train has entered section B4, since relays Y4 and X4 control the indicator 4P. The object of the back point on relay B4 is to allow the signalman to put lever 47 normal supposing one train is standing in section A4 and another train in either the approach or distant sections. If the first train should pass to section B4, it would be proper to let the second train through crossover 32 onto track 3, but the indicator 4P would be de-energized and therefore this back contact on relay B4 is necessary to permit the route to be changed. The slow release also acts as a shunt around the contact on indicator 4P. It should be noted that the slow release and the back contact on relay B4 are inoperative with a train standing in section A4, in other words they act only on the approach locking. The track circuit in section A4 is a detector circuit inasmuch as it locks the latch of lever 47 up with the lever normal, thereby preventing movement of any of the switch or facing point lock levers for the route governed up to signal 40. Relays B4 and B3 control a lock on facing point lock lever 17, locking this lever reversed. This acts as a detector lock when a train is standing in either circuit.

NOTE TO FIGS. 2001-2008.

Insulated switch rods to be used on all switches in track circuit limits.

Insulated connections to be used on all detector bars.

Resistances:

Indicators	1000 ohms.
Repeating relays	1000 ohms.
Electric locks	500 ohms.
Electric slots	100 ohms.
Track relays	5 ohms.

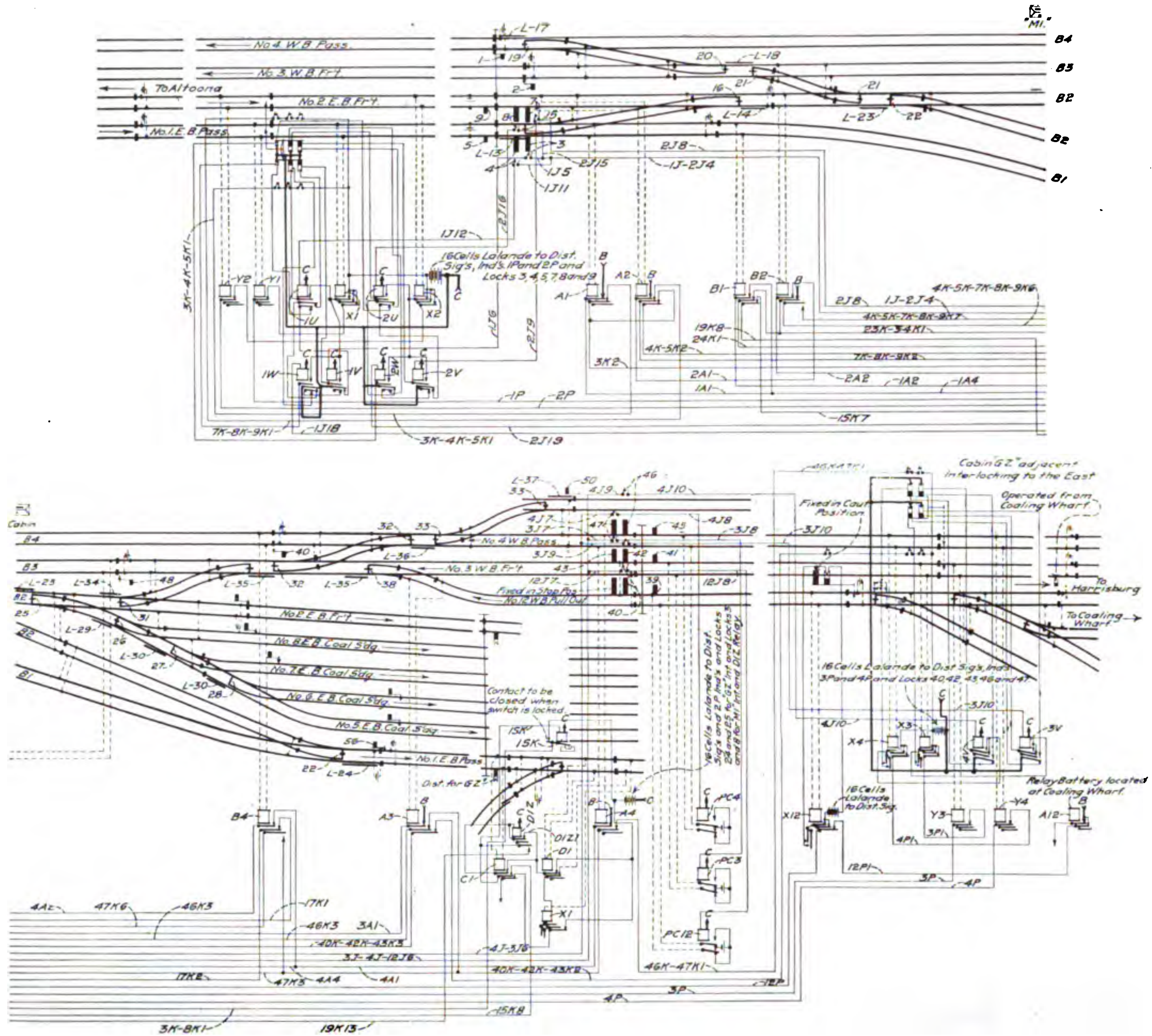
Indicator and relay symbols:

1A, 2A, etc.—Block indicators.
1P, 2P, etc.—Approaching indicators.
A1, X2, Y1, etc.—Track relays.
1V, 2V, etc.—Signal relays.
A1Z, B1Z, etc.—Repeating relays.

Wire numbering, these symbols indicate things controlled:

Track Nos. 1A-2A, etc.—Block indicators.
" " 1P, 2P, etc.—Approach indicators.
" " 1J, 2J, etc.—Distant signals.
" " A1Z, B1Z, etc.—Repeating relays.
" " 1SK—Electric lock on hand switch.
Lever Nos. 4K, 14K, etc.—Electric locks.

The consecutive wire number follows the letter of the symbol (the last letter in combined symbols).



Figs. 2001-2002. Electric Locking Circuits, Denholm. Pennsylvania Railroad.

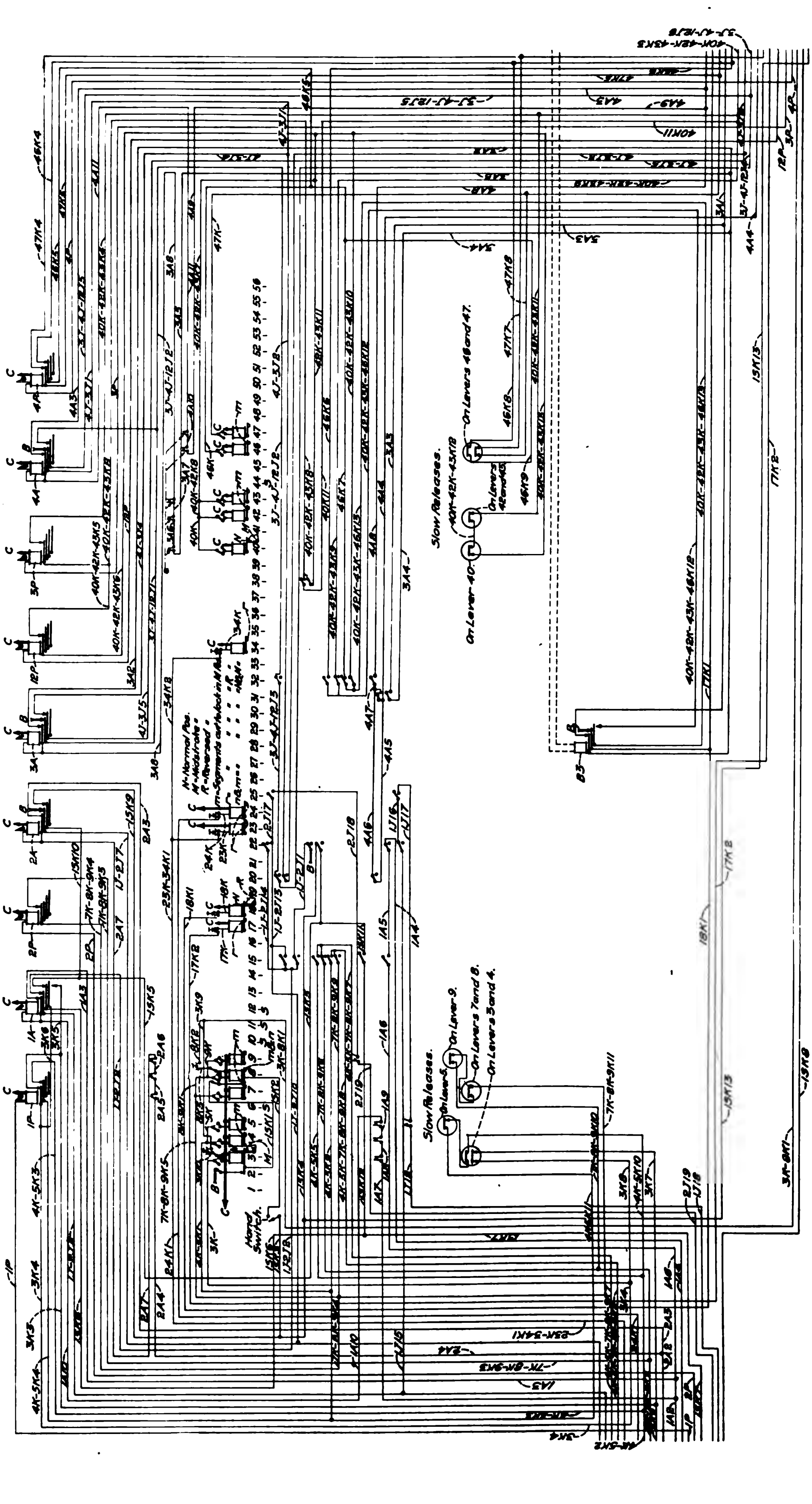


Fig. 2003. Electric Locking Circuits, Denholm. Pennsylvania Railroad.

NOTE.—Figs. 2001-2003 are parts of a single diagram. The track plan, Figs. 2001-2002, is divided opposite the cabin and the wiring in the cabin, Fig. 2003, is inserted between them.

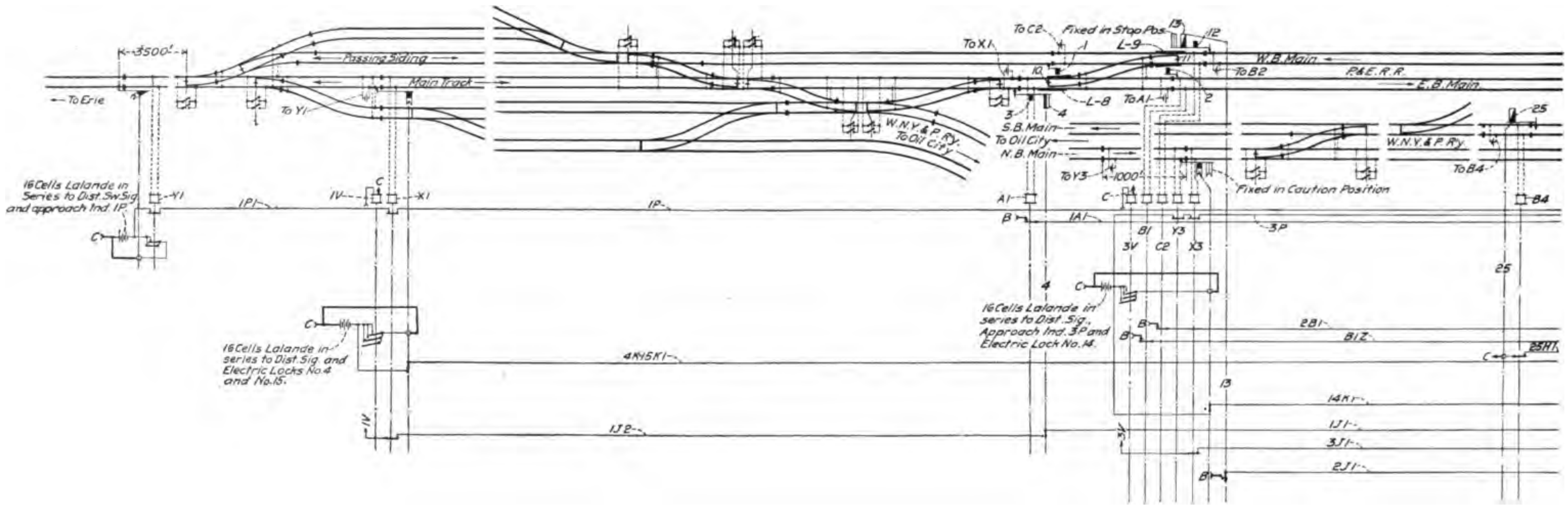


Fig. 2004. Electric Locking Circuits, Irvineton. Pennsylvania Railroad.

Figs. 2004-2005 show electric locking circuits in use at Irvineton, Pennsylvania Railroad.

This is a mechanical interlocking plant with slotted signals. The circuits for route governed by signals 23 and 13 may be considered as typical. The circuit for lock 23 starts from the battery at right of Fig. 2005, and passes through the circuit controller on the distant signal, wire 13K-23K1, from contact on relay A2, wire 23K2, front contact on indicator 2P, wire 23K, circuit controller on tappet (lever 23), lock 23 to common and back to battery. Two parallel circuits are run around the front contact on indicator 2P, one through the back point on indicator 2A, the other through the show release.

The circuit for indicator 2P starts from the same battery and passes through the front contacts of relays Y2 and X2, wire 2P, indicator 2P, to common.

The circuit for indicator 2A starts from the main battery and passes through the front contact of relay A2, wire 2A1, front contacts of relays B2 and C1, wires 2A2 and 2A5, circuit controller on lever 23, wires 2A6 and 2A, indicator 2A to common. As soon as the indicator is energized its front armature contact forms a shunt direct from wire 2A2 to 2A, so that the indicator will remain energized after the circuit controller on lever 23 is opened, in the same manner as a stick relay. This "stick" feature makes it necessary for lever 23 to be put into the full normal position after each train. A shunt circuit through wire 2A3, circuit controller on lever 17, and wire 2A4, bridges the contact on relay B2 when 17 is reversed. This is to allow a train to be moved from signal 23 through switch 17 reversed, while another train is standing between signals 27 and 13. A tap is taken off from wire 2A6, through the second circuit controller on lever 23, to the slot on signal 23 (not shown).

Lock 23 is de-energized with a train in the approach, distant or home circuits, or with distant signal clear. It should be noted that indicator 2A is controlled beyond the limits of section A2 and that its back point picks up the lock provided the distant signal is normal and no train is in the home circuit, A2. This

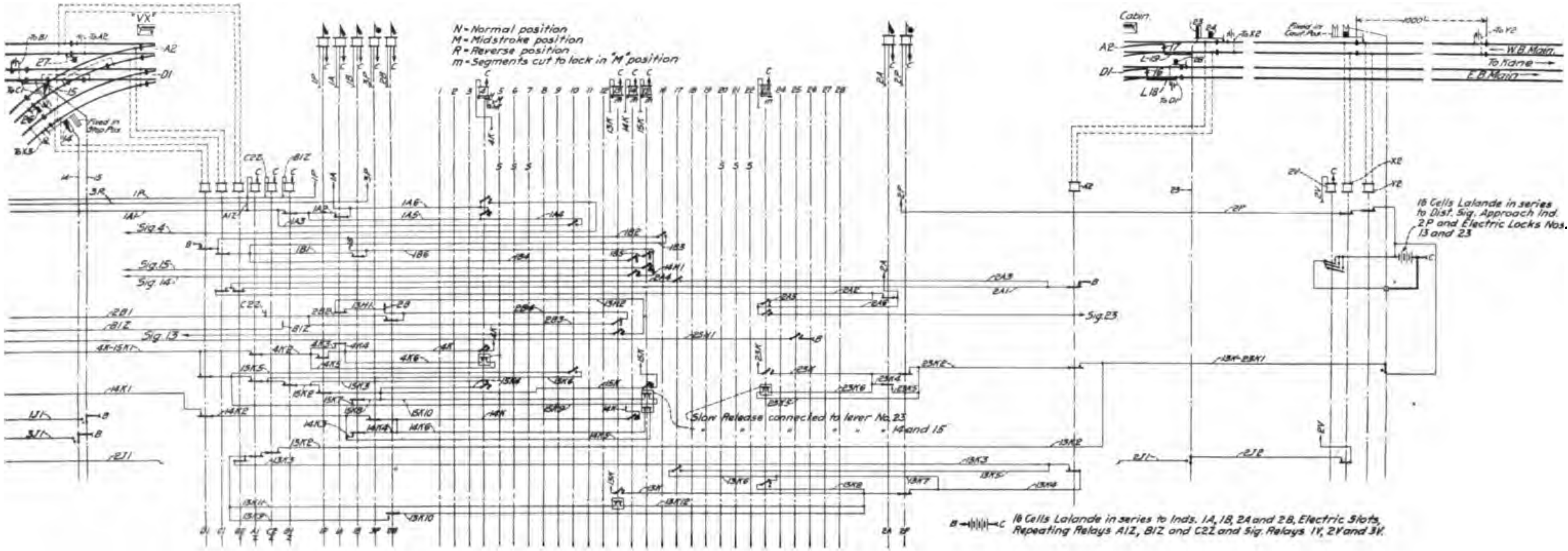


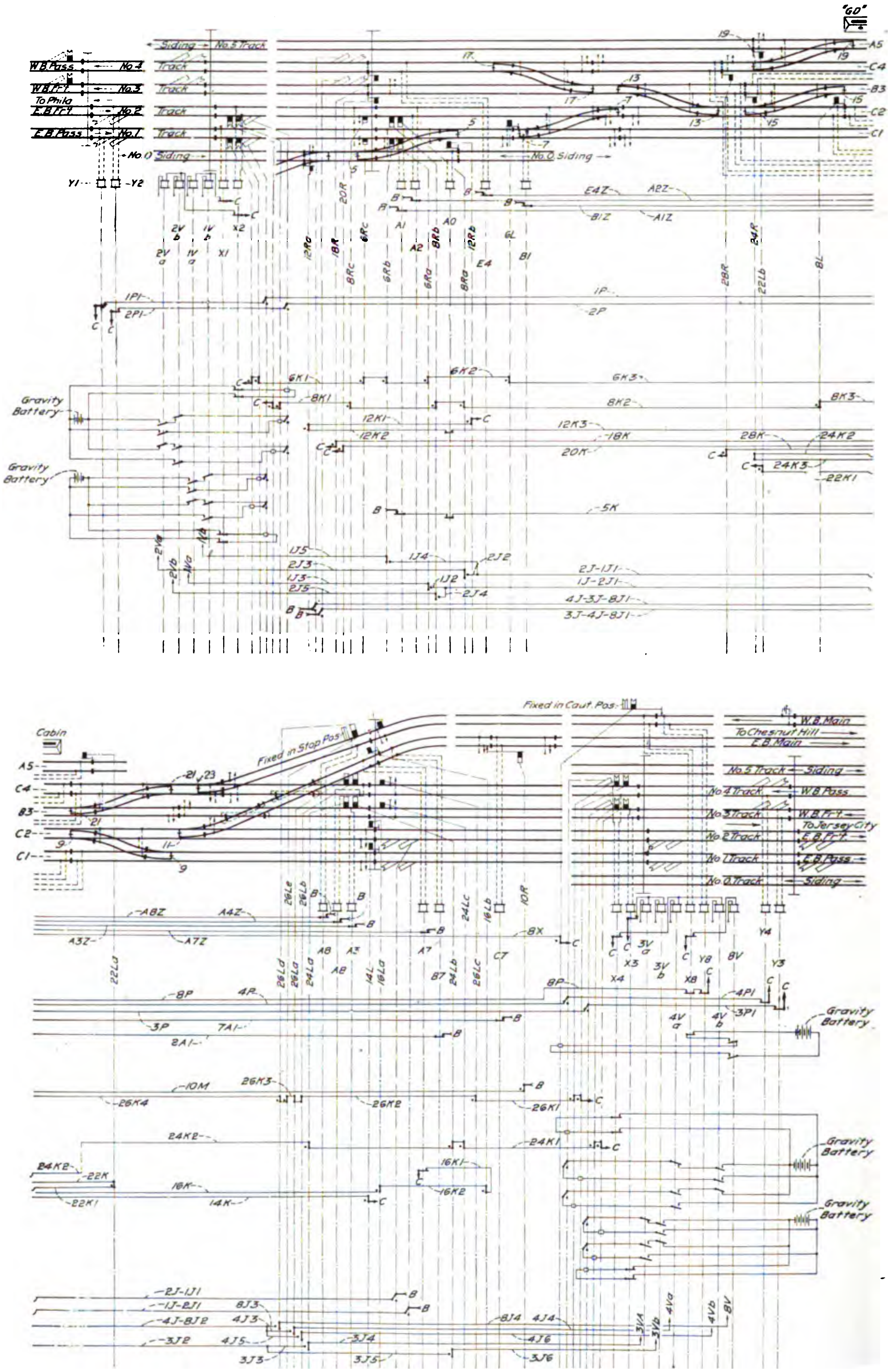
Fig. 2005. Electric Locking Circuits, Irvineton. Pennsylvania Railroad.

NOTE.—Figs. 2004 and 2005 are parts of a single diagram. The right hand end of Fig. 2004 joins the left hand end of Fig. 2005.

indicator remains de-energized until lever 23 is fully normal. This extends the releasing section giving the signalman more time to restore his lever after a train passes, in case a following train has entered track circuits Y2 or X2, and is to proceed on a different route. Leaving the signal lever reversed will not cause trouble because the slot circuit is then de-energized and the signal will remain in the stop position until the lever is put normal and again reversed.

The lock on lever 13 is controlled through wire 13K2 which taps off from wire 13K-23K1, in substantially the same manner as lock on 23. Thus the advance and home signal lever latches are both locked up (lever normal) if these signals have been cleared for an approaching train. The slow releases perform the same function as the back point on the home or advance indicators.

Figs. 2006-2008 show electric locking circuits at North Philadelphia, Pennsylvania Railroad. This is an electro-pneumatic plant. Both approach and detector locking is provided. The approach locking and release circuits are similar to those shown for Irvineton (Figs. 2004-2005). Locking of levers is accomplished through the indication magnets. The track circuits are supplied with current from storage cells. The detector locking is accomplished as shown in Fig. 2009a by breaking the switch lever circuits through track or repeating relays, or indicators for the sections in which the switch occurs. The circuit for switch 5 shows the simple arrangement; most of the other switches are provided with route locking controlled through stick relays; No. 9 may be considered as typical.



Figs. 2006-2007. Electric Locking Circuits, North Philadelphia. Pennsylvania Railroad.

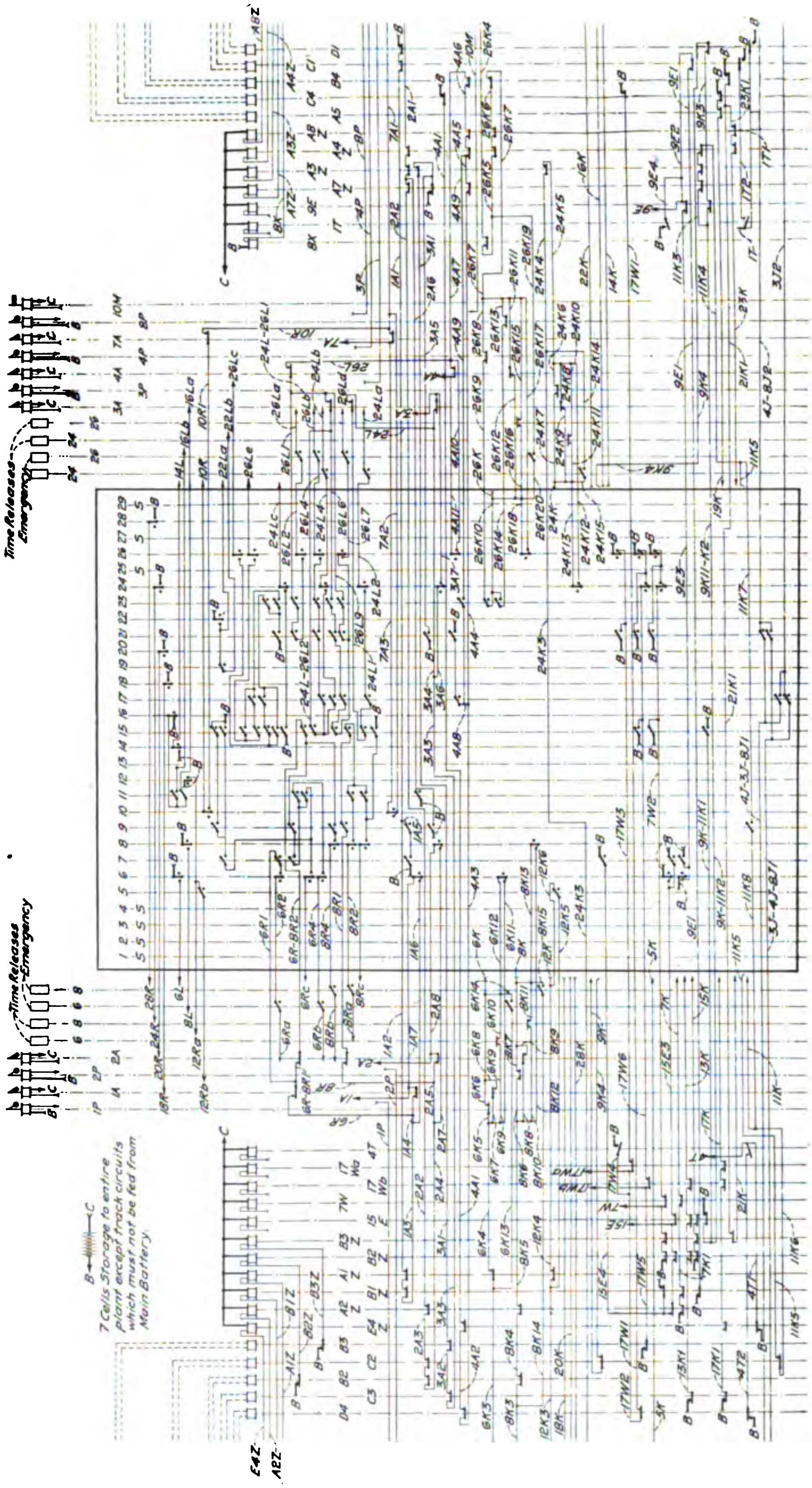


Fig. 2008. Electric Locking Circuits, North Philadelphia. Pennsylvania Railroad.

NOTE.—Figs. 2006-2008 are parts of a single diagram. The track plan, Figs. 2006-2007, is divided opposite the cabin, and the wiring in the cabin, Fig. 2008, is inserted between them.

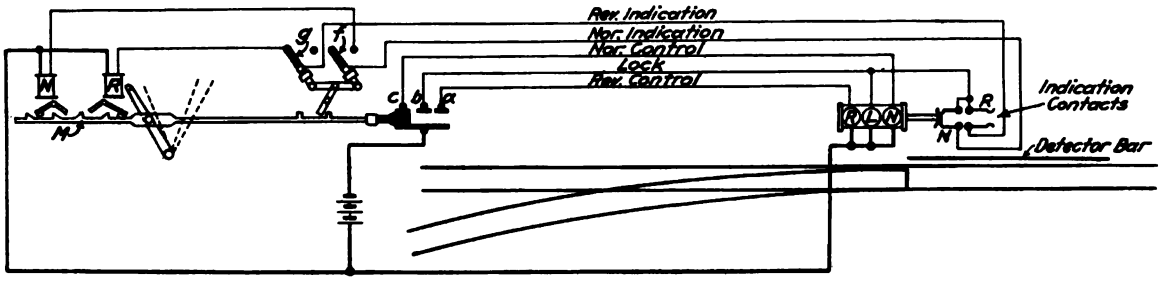


Fig. 2009. Circuits for Electro-Pneumatic Switch Movement Without Detector Locking.

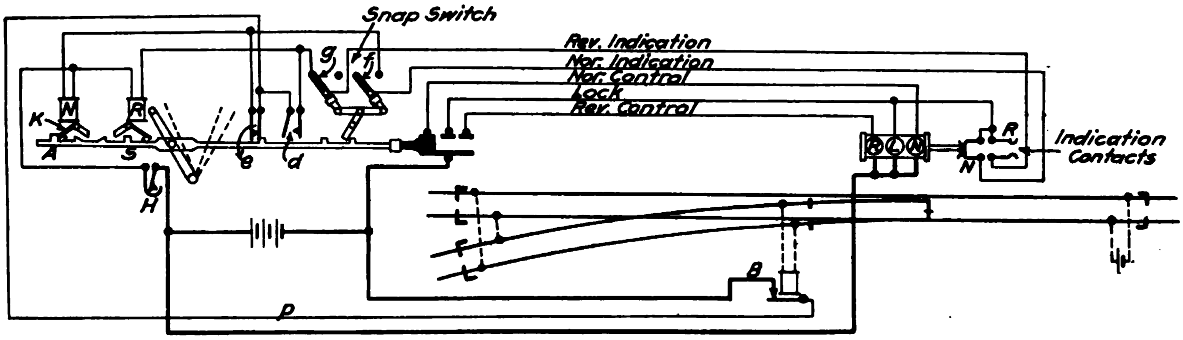


Fig. 2009a. Circuits for Electro-Pneumatic Switch Movement with Detector Locking.

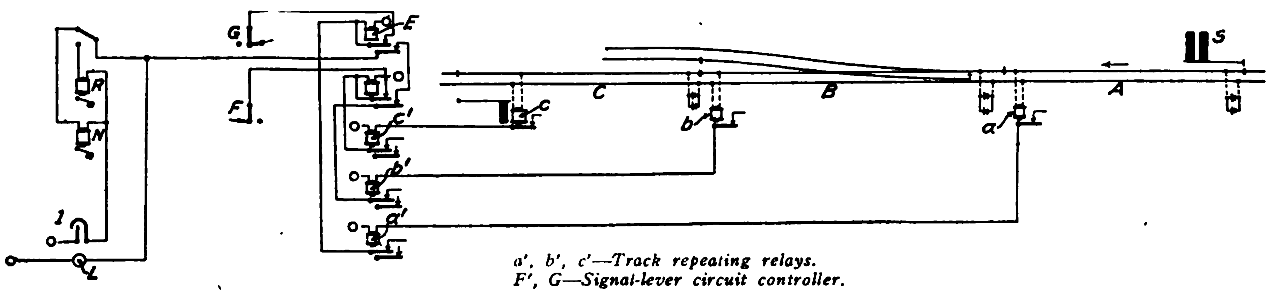


Fig. 2010. Typical Route and Detector Locking Circuits for Electro-Pneumatic Interlocking Plant. Delaware, Lackawanna & Western.

In electro-pneumatic interlocking for indication purposes a switch lever is unlocked near the end of the stroke to allow a movement to the extreme position, whereas for electric detection the lever is unlocked to allow a movement starting from the extreme position. As these two lockings are never required at the same time they can, in the electro-pneumatic machine, be secured by use of the same apparatus through a modification of the lock segment and latch, and an addition to the circuits controlling the normal and reverse indication magnets.

The standard form of segment is shown in Fig. 1905, and its operation indicated in Fig. 2009. This differs from elementary form shown in Figs. 1913-1916 in the use of the lug M engaged by the reverse indication armature when energized (and also one for the normal armature). In reversing the switch, the magnet R should remain de-energized until lug M passes the point where the armature of R could engage it. If for any reason (such as a cross in circuits, etc.) R should be energized improperly, its armature would engage with M and prevent further movement of the lever. This lug also operates to prevent an indication magnet from acting falsely through residual magnetism, and also from being blocked or "plugged" by a careless repairman.

The modified form of segment is shown in Fig. 1906 and its operation in Fig. 2009a. The armature K of the normal magnet N engages one side of the dog A, with the lever in the extreme normal position; in other words, it engages for detector locking purposes the other side of the same dog which is engaged for indication purposes during a movement of the lever from reverse to normal. The additions to the circuit include the wires B and *p*, passing through a front contact on the track relay, and the lever circuit controllers *e* and *d*, a lever latch circuit controller H also being added for the purpose of reducing consumption of current when not required.

With the lever in the extreme normal position shown in Fig. 2009a, the detector lock circuit starts from battery and passes through wire B, front contact on the track relay, wire *p*, circuit controller *e*, magnet N, latch contact H, to common; thereby energizing N, and raising K from engagement with A, which unlocks the lever. The first movement of the lever opens *e;* controllers *d*, *g* and *f* remain unaffected until last portion of the stroke, when *g* and *f* are reversed and *d* is closed. In the extreme normal position, as shown in the diagram, the only current that can energize N must pass through the contact on the track relay and similarly, with the lever in extreme reverse position, current for R must pass through the same relay contact and controller *d*. The circuit breakers *e* and *d* are the same as the roller band controllers employed for signal circuits. The dog S engages with the armature

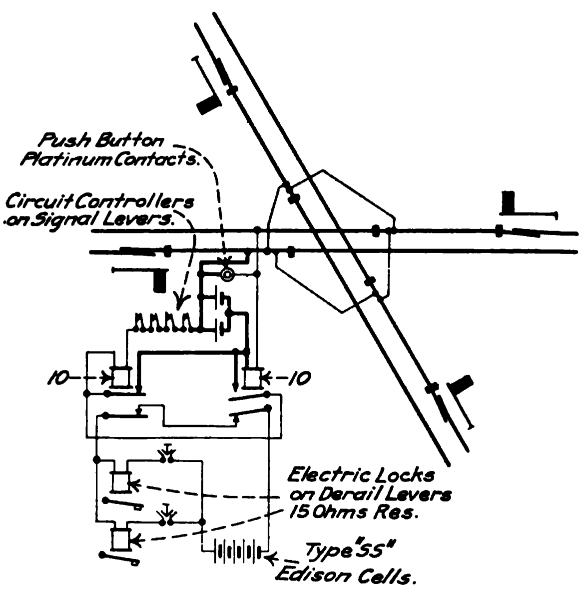


Fig. 2011. Electric Locking Circuits for Single Track Crossing. New York Central & Hudson River.

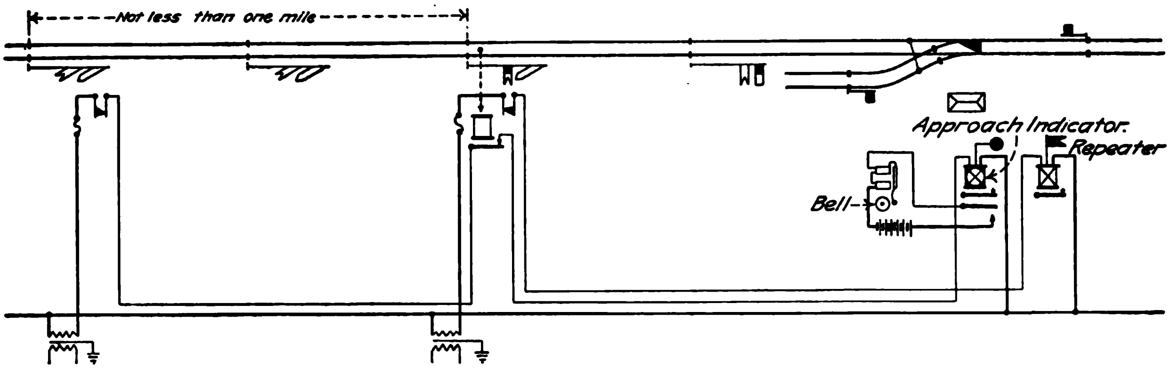


Fig. 2012. Typical Circuits for Approach Indicator and Distant Repeater (Automatic Signals are Overlapped). Electric Zone, New York Central & Hudson River.

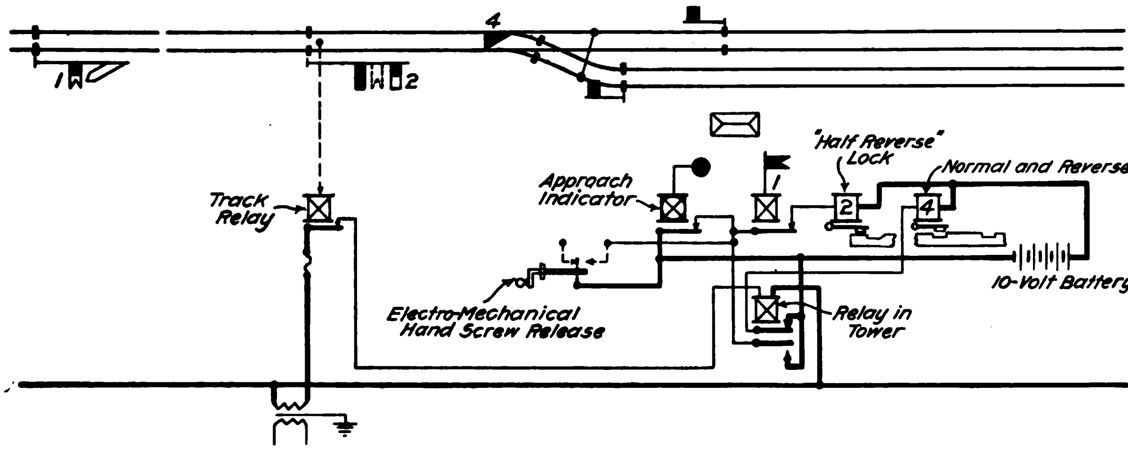


Fig. 2013. Typical Circuits for Approach Locking and Electric Detection at an Electric Interlocking Plant. Electric Zone, New York Central & Hudson River.

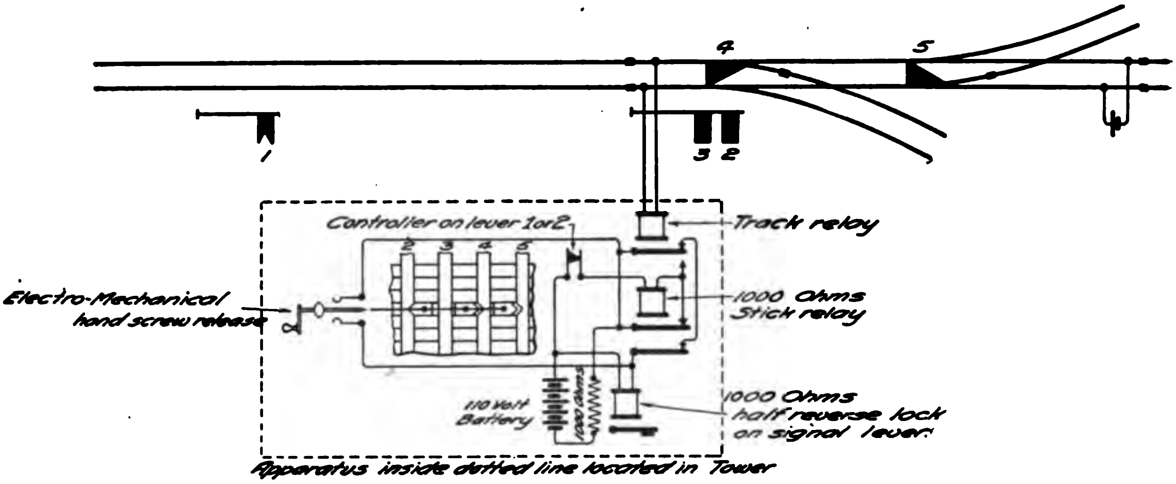


Fig. 2014. Electric Locking Circuits, with Electro-Mechanical Hand Release for Electric Interlocking Plant. General Railway Signal Company.

of R when the lever is reversed in the same manner as A with K when normal.

Fig. 2010 shows typical electric locking circuits used at the Hoboken Terminal of the Delaware, Lackawanna & Western, which provide route locking and also electric detection. The track is divided into convenient sections between signals so as to allow maximum freedom of lever movements; *a*, *b* and *c* are track relays for circuits A, B and C, respectively. Each of these track relays controls a repeating relay, *a'*, *b'* and *c'* which simply repeat the action of the track relays. Relays *a'* and *c'* control stick relays in connection with the circuit controllers F and G, on the signal lever. Suppose a train to be approaching signal S; to permit it to proceed the signalman reverses the signal lever to the left, opening circuit controller G, but keeping F closed. As soon as the train enters section A relays *a* and *a'* are de-energized; when *a'* opens (G already being open) stick relay E is de-energized, opening the circuit for the lock magnet N on the switch lever. As the train passes from section A to section B the relay *b'* is de-energized, holding the circuit for lock N open. Relay E picks up as soon as the rear of the train clears section A. When the train enters section C, relay *c'* opens, but as F is still closed the stick relay (directly above relay *c'*) remains closed, and as soon as the rear of the train leaves section B, relays *b* and *b'* are energized, and the circuit for lock N closed. If the switch is reversed the lock R is in circuit instead of N (see Fig. 2009a). In a movement in the opposite direction the lower stick relay would be de-energized and E would remain energized. Thus circuits are provided to lock all switches in the route when a train passes the governing signal at clear. The switches remain locked until the train has passed over them or has backed off the route. Each switch is released as soon as a train has cleared the fouling point. Thus a route cannot be changed ahead of a train, but may be changed as soon as the rear of the train has passed. The contact 1 is operated by the switch lever latch in the same manner as H in Fig. 2009a. The electric lamp L is connected in multiple with the lock magnets. It is placed just below the lever as shown in Fig. 2061, and is lighted while the switch is free to be moved, but it is extinguished when the switch is locked by the presence of a train.

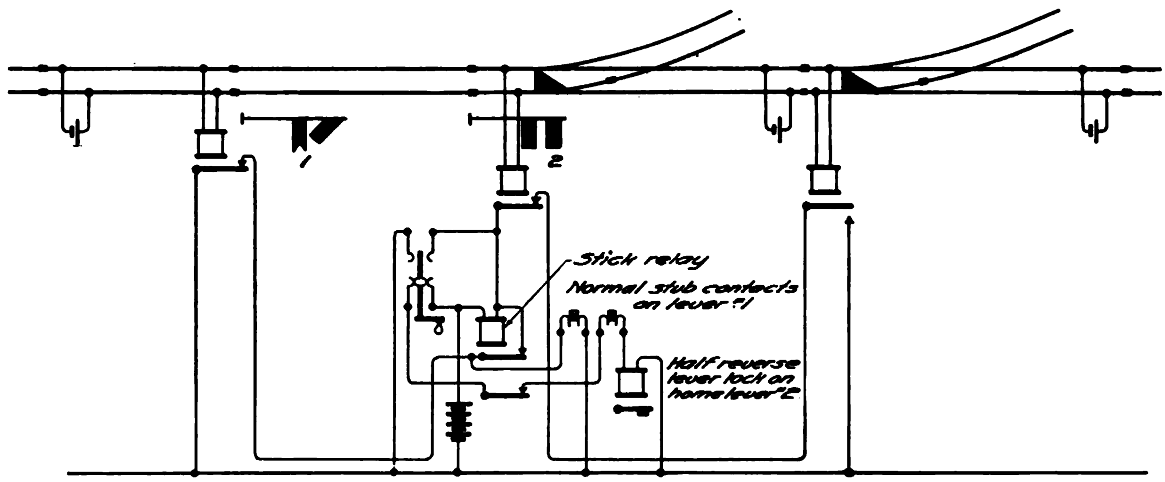


Fig. 2015. Typical Electric Approach Locking Circuits, with Electric Hand Release for Electric Interlocking. General Railway Signal Company.

For electric locking circuits used in connection with the electro-pneumatic push button machine, see Fig. 1956. For electric locking circuits for drawbridge protection, used with the electro-pneumatic interlocking machine, see Fig. 1965.

In Fig. 2011 are shown an arrangement of electric locking circuits used at interlocking plants protecting simple crossings. The track circuit is normally open. The track battery supplies not only the track circuit, but also a 10-ohm stick relay whose circuit is carried through controllers on the home signal levers so that the reversal of any one of them will de-energize the stick relay. The stick relay cannot again pick up until all the home signal levers are normal and the track relay has been energized by the presence of a train. The stick relay and the track relay both control, through a front and back contact, respectively, the circuit of the two electric locks which act on the derail levers. The circuits for these two locks are also carried through normally open floor pushers in order to economize in current. A push button is provided to energize the track relay and release the locking in case it becomes necessary to change a route that has been set up; but the push button will not release the locks unless the signals are all in the stop position. Fig. 2012 shows an approach indicator and distant signal repeater for an interlocking plant. In this case the exterior circuits are energized by alternating current. The approach indicator is controlled by a circuit from the transformer at the extreme left, through a normally closed circuit controller on the automatic home signal, the track relay point at the distant interlocked signal, the indicator, to common. A back point on this indicator closes a local bell circuit. The indicator circuit is not run through a circuit controller on the intermediate automatic signal because the circuits for these signals are overlapped. Therefore, the indication will be maintained for both sections by the one circuit controller. The repeater is operated by a normally closed circuit controller on the distant signal arm.

Fig. 2013 shows how the above instruments are made use of in approach and detector locking at an electric interlocking plant. The half-reverse lock (No. 2) holds the home signal lever against the indication stop when being moved to the normal position. This lock is controlled by the approach indicator and the repeater. If lever No. 2 has been reversed and the home and distant signals cleared, a train approaching within a mile of the distant signal will de-energize the lock and prevent lever 2 from assuming the full normal position. However, it may be moved far enough to put the signal at stop. It will be noticed that the notch is square on one side and sloped off on the other; this is to allow the lever to be reversed at any time. There are two shunt circuits around the contact of the approach indicator, one through the screw release, the other through the back point of the repeating track relay. Thus by working the release the approach indicator point can be shunted out. The mechanical action of this release will be considered in connection with Fig. 2014. It is to be used if a wrong

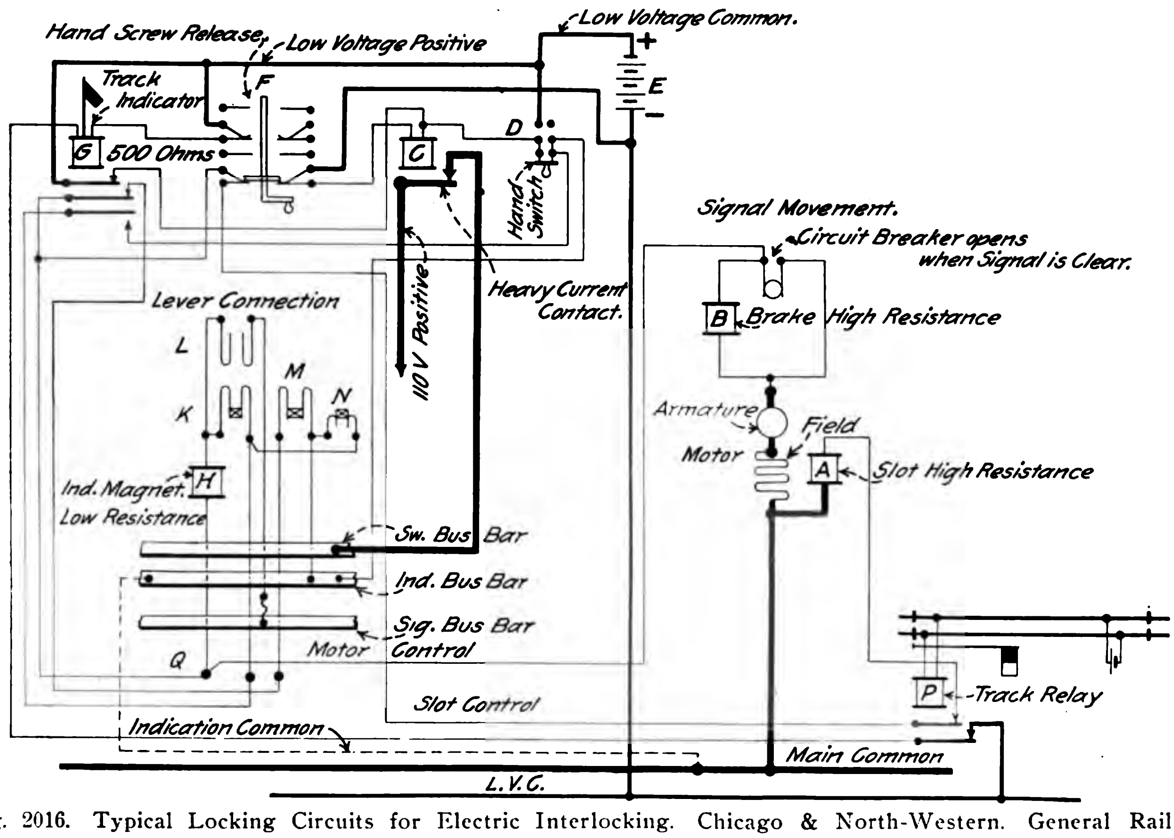


Fig. 2016. Typical Locking Circuits for Electric Interlocking. Chicago & North-Western. General Railway Signal Company.

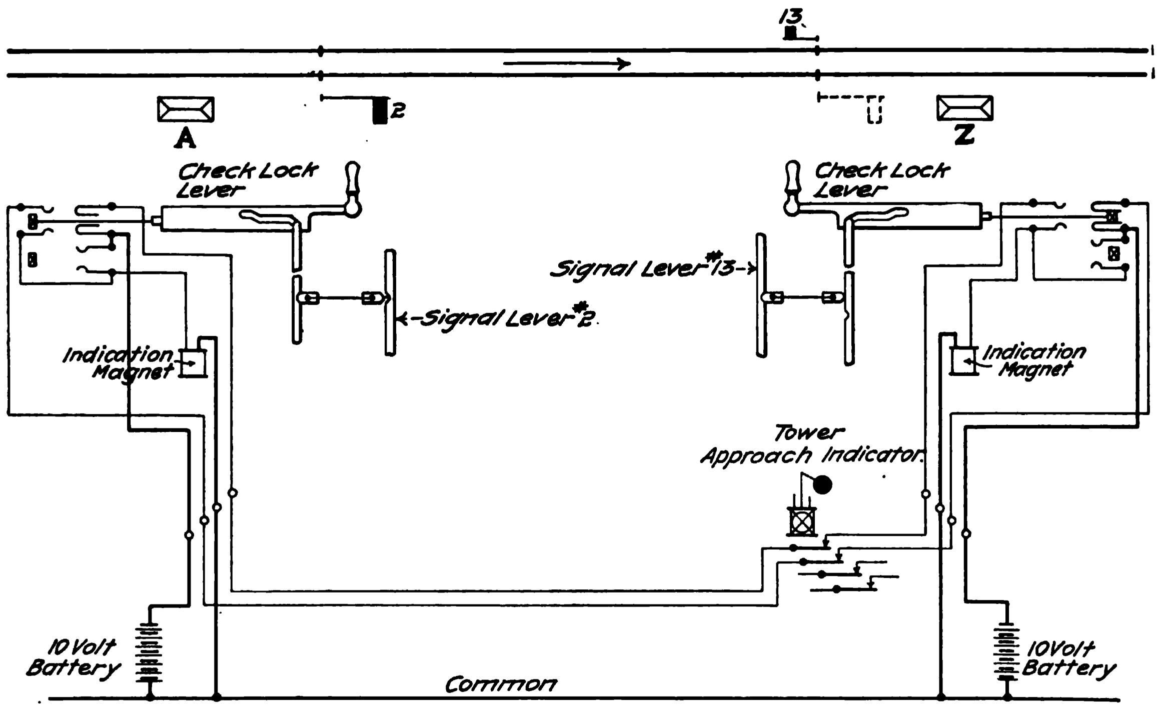


Fig. 2017. Check Locking Circuits for Electric Interlocking. General Railway Signal Company.

route has been set up by mistake, and a train for another route is waiting at the home signal. The back point of the repeating relay performs the same function as the release when the relay is de-energized. This is to permit the lever to be fully restored to the normal position preparatory to setting up a new route, if one train has passed the home signal and another is approaching. This relay is controlled by the home track relay. No provision is made for shunting out the distant repeater for the reason that should the distant signal stick clear a train might accept it and not be able to stop at the home signal. In such a case it would be dangerous to have any other than the high speed route set up. Lock No. 4 acts on the switch lever, locking it in either full stroke position. This lock is controlled by the repeating relay so that a train in the home circuit locks the switch in either the normal or reverse position, as the case may be. It is not released until the train has passed off the track circuit.

Fig. 2014 illustrates a route locking circuit and also the mechanical action of the hand release (see Figs. 2013 and 2898). The lock acts on the home signal lever as in Fig. 2013. It is controlled through front points of the stick and track relays, in parallel with the release contacts. The stick relay is controlled by its own front point and a controller on either the home or distant lever as desired, and is restored only by a back contact on the track relay when the controller is closed. Therefore, the reversal of the lever actuating the controller opens the stick relay, de-energizing the lock. The lock remains in this condition until a train has passed onto the home track circuit and the circuit and the signals have been put normal. It is necessary to restore the signals while the train is on the circuit or the lock will not release. The hand release will shunt out the relay contacts and energizes the lock regardless of either relay. It has a projection which when screwed in butts against the locking bar to which is attached all the dogs controlled by the home signal lever. Thus the route is kept locked while the lever is being released. This makes it necessary to restore the release to its normal position before the route can be changed.

Another arrangement of circuits for approach locking is shown in Fig. 2015. Here, as in Fig. 2014, no indicators are used. The lock is controlled by a circuit controller on the distant signal lever, a stick relay, and the normal contact of the hand release. The stick relay is controlled by its own point and two parallel circuits, one through the approach track relay, the other through a second circuit controller on the distant signal lever. It is restored either by a back point on the advance track relay through front contact on the home track relay, or by the upper contact of the hand release. The lock is de-energized by the reversal of the distant signal lever. This opens one of the stick relay circuits also, so that a train in the approach section will open the stick relay. The stick relay will remain open until the train has entered the advance circuit. This circuit restores the lock, whether a second train is approaching or not, provided the distant signal lever has been put normal. With this circuit a route may be lined up and everything put normal again, provided no train is approaching, without using the hand release. This could not be done with the circuits in Fig. 2014. The release used in Fig. 2015 is entirely electrical. The first turns break the lock circuit while the last close the stick relay circuit. It is necessary to restore it to its normal position before the lock can pick up and the route be released. The lock is used to hold the signal lever in the "half reverse" position, as in Fig. 2013, so that the signal itself may be put in the stop position at any time in case of emergency.

Route and detector locking circuits for a General Railway Signal Company's electric interlocking plant are shown in Fig. 2016. The locking is secured by cutting the signal indication circuit, as explained in connection with Figs. 1999-2000, but on account of the "dynamic" indication current being present for only a short time after the signal mechanism has assumed its normal position, the circuit arrangement is somewhat different from that shown in those illustrations.

The switch bus bar is divided into sections, each section supplying current to the switches in one route only. Reversal of the signal lever energizes the slot A and clears the signal, through contacts L. The slot circuit is as follows: From the signal bus bar through contact L, indication magnet H, binding post Q, lower left hand contact on screw release F, upper contact on track relay P, slot magnet A, to common. If, after the signal is cleared, the lever is moved toward normal, the signal will go to the stop position and the dynamic indication current, generated by the signal motor, will flow through the main common, indication common, indicator bus, controller contacts M, indicator point, binding post Q, circuit breaker on signal, to motor. This will give no indication at the lever, but will act as a snubbing circuit to slow up the motor and prevent shock to the mechanism. If it becomes necessary to change the route after a signal has been cleared, the hand screw release F (see Figs. 2893-2895) must be first reversed. This opens the slot circuit and restores the signal to normal; it also opens the circuit for relay C. These circuits cannot again be restored until the release is put normal. Relay C controls the circuits for all the switches in the route so that when it is open no switches can be moved. When the screw release is reversed it breaks the circuit for indicator G. The signal lever may then be restored to the normal position. When indicator G is de-energized, either by the presence of a train on the track circuit or by the screw release, it breaks the circuit of relay C and the snubbing circuit just described, and its back point closes. This completes the indication circuit as follows: From motor through main common, indication common, indication bus, hand switch D, indicator back point, controller contact K, indication magnet H, binding post Q, circuit breaker on signal, to motor. This gives the indication and releases the lever. With the lever normal the indication circuit is kept closed through controller contact N in order to provide cross protection (Figs. 1665, 1772-1773). If for any reason indicator G should fail, it would keep relay C open and prevent the movement of any switches in the route. To move a switch under such circumstances hand switch D is reversed. This closes a local circuit for relay C, but opens the signal indication circuit. A switch can then be moved, but to get a signal indication D must be restored and this would again open circuit for C, thus preventing an improper movement. If the hand switch D should be operated while the screw release is reversed the

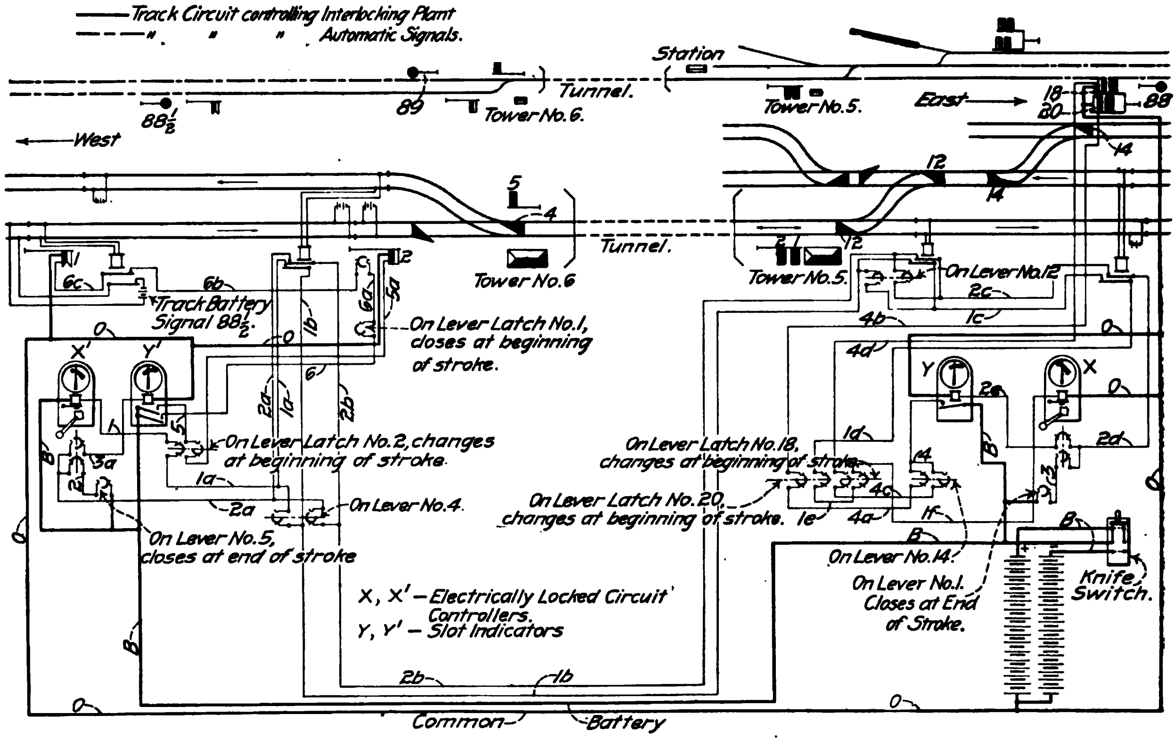


Fig. 2018. Check Locking Circuits and Track Diagram, Bloomingburgh Tunnel. New York, Ontario & Western.

relay C could not close because its return is cut through the lower right hand contact on the release.

CHECK LOCKING.

Where two interlocking plants are situated close together and each has signals governing toward the other on the same track, it is necessary to provide means to prevent any two such opposing signals from being cleared at the same time. Such an arrangement of apparatus is called "check locking."

Fig. 2017 illustrates a method of accomplishing check locking at two electric interlocking plants. Each plant is provided with a check lock lever. A is the master plant as its signal (2) governs in the normal direction of traffic, and under normal traffic conditions may be operated without interference from the check locking. The check lock levers are interlocked with the signal levers. The check lock lever at A, when reversed, locks lever 2 normal and at Z, signal lever 13, when reversed, locks the check lock lever reversed.

To clear signal 13 for a reverse movement, the check lock lever at A is first reversed; this locks signal 2 normal. In reversing this lever the lower contact block bridges the two lower springs at the reverse indication stop, closing a local circuit through the indication magnet, and permitting a full reversal of the lever. The upper contact block also bridges the two upper reverse contact springs, which closes a circuit from the 10-volt battery at A, through the upper line wire, the upper contact of the approach indicator at Z (insuring that the track section between the two towers is unoccupied) to the upper reverse contact spring of the check lock lever at Z. This lever is now reversed as far as the indication stop. When this is reached, its upper contact block bridges the contact springs at that point, completing the circuit just traced, through the indication magnet to common and back to its battery at A. This energizes the indication magnet and permits the check lock lever at Z to complete its reverse stroke, releasing the mechanical locking which has, up to this time, held signal lever 13 in its normal position. In this last portion of the stroke it also breaks the contact just made, de-energizing the indication magnet.

Trains may now be forwarded from Z to A, their movement being governed by signal 13.

To restore the normal traffic (signal 13 having been put in the stop position), the check lock lever at Z is moved to its normal position, locking signal lever 13 normal. In going to this position the lower contact acts in the same manner as with the lever at A, when being reversed. In the normal position of the lever at Z its upper normal contact springs are bridged, closing a circuit from the 10-volt battery at Z, through the second contact on the approach indicator (again insuring that the track is clear between the two towers), the lower line wire, to the upper normal contact spring of the check lock lever at A. This lever is now moved against the normal indication stop, completing its indication circuit in the same manner as the lever at Z when reversed. Thus after both check lock levers are restored to their full normal position, signal lever 2 may be reversed, and traffic resumed in its normal direction.

Fig. 2018 shows check locking circuits in use between two interlocking plants situated at each end of the Bloomingburgh Tunnel, on the New York, Ontario & Western. This installation comes near being single track controlled manual blocking; and, in fact, the same may be said of any effective form of check locking.

X and X', electrically locked circuit controllers (see Figs. 267-268), are used instead of check lock levers. Indicators Y, Y' control the slot circuits and are controlled by X and X'. The circuit for X and X' is as follows: Wire B, magnet X', wire 1, circuit controller on latch of lever 2, wire 1 *a*, track relay point, wire 1 *b*, track relay points at tower 5, wire 1 *d*, circuit controller on latch of lever 20, wire 1 *e*, circuit controller on latch of lever 18, wire 1 *f*, magnet X, to wire O. Wires B and O are the two main battery feeds. It will be noted that reversal of the knife switch reverses polarity of feeds, thereby counteracting any tendency toward residual magnetism in the instruments.

To send a train from tower 5 to tower 6 no manipulation of X or X' is necessary. Signalman at 6 reverses lever 5, thereby closing circuit controller on its tappet. Current now flows from B at tower 6, through circuit controller on lever 5, wire 2, controller X', wire 2 *a*, point of track relay, wire 2 *b*, track relay points at tower 5, wire 2 *d*, controller X, wire 2 *e*, magnet of Y, to O. This energizes Y and closes the slot circuit for signal 18 or 20 (according to the position of 14), when latch of either is raised. Either signal can now be cleared for a train, but such action opens the circuit for X and X' and locks them in their normal position. Lever 12 must be reversed before 18 or 20. This shunts out the circuits for X, X' and Y from the points of eastbound track relay. This permits a train to stand on the eastbound circuit beyond the fouling point of the crossover, while another is making a normal westbound movement. The circuit controller on lever 14 selects slot circuits for signals 18 and 20.

To move a train from tower 6 to tower 5, controllers X and X' and lever 1 (at tower 5) must be reversed; also switch and derail 4 at tower 6 must be reversed. This closes a circuit from B at tower 5, through controller on latch of lever 1, wire 3, lower contact of X (now closed), wire 2 *d*, points of track relays, wire 2 *b*, circuit controller of lever 4 (now closed), wire 2 *b*, circuit controller on lever 4 (now closed), wire 2 *a*, upper contact of X' (now closed), wire 3 *a*, magnet of Y', to O. This energizes Y' and closes slot circuit for signals 1 and 2 when their lever latches are raised. Raising the latch of 2 breaks the circuit of X and X', locking them reversed.

The presence of a train on the tunnel track circuit opens both control circuits, de-energizing the controllers X and X', and indicators Y and Y' which in turn opens their respective slot circuits automatically putting the signals in the stop position, holding them there until the track circuit is clear, and also locking controllers X and X' in whichever position they were last left. When crossover 12 is normal the track circuit on the eastbound track at tower 5 has the same effect, and when switch 4 is normal the same is true of the westbound track circuit at tower 6.

After the passage of a train in either direction it is not necessary to manipulate X and X' for a following movement, but they must be changed for a movement in the opposite direction. Reversal of either X or X' alone has no effect on Y or Y', as they are then thrown into a closed circuit without battery.

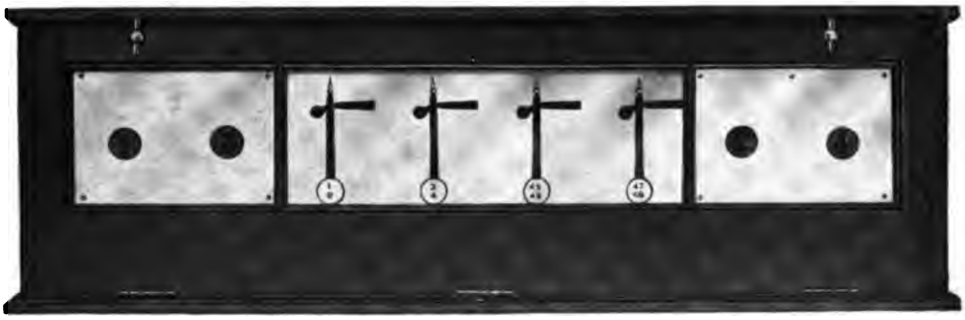


Fig. 2019. Group of Annunciators and Semaphore Indicators. The Union Switch & Signal Company.

Fig. 2020. Train Director's Board and Instruments. Delaware, Lackawanna & Western. The Union Switch & Signal Company.

Fig. 2021. Train Director's Board. General Railway Signal Company.

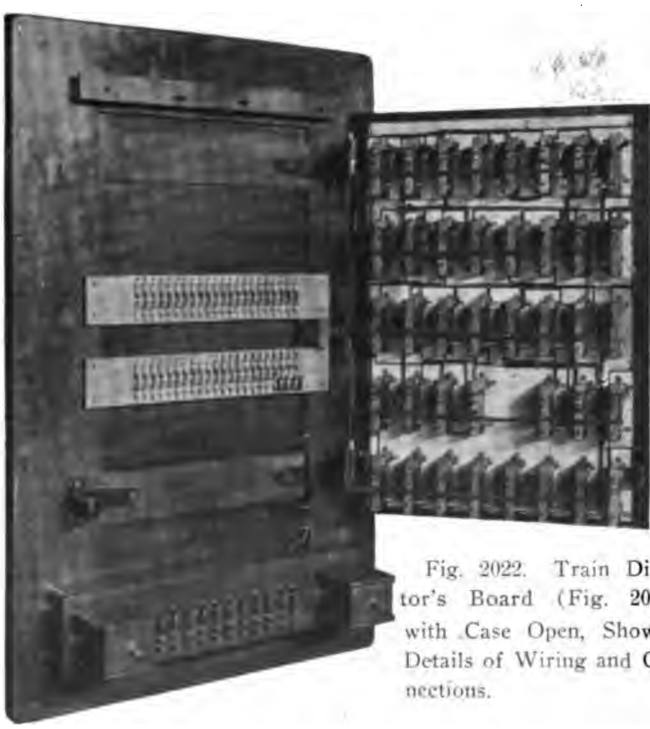


Fig. 2022. Train Director's Board (Fig. 2021), with Case Open, Showing Details of Wiring and Connections.

Fig. 2023. Group of Indicators. General Railway Signal Company.

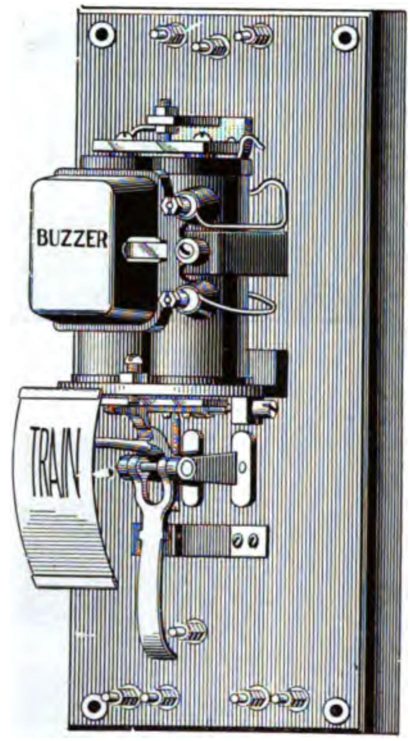


Fig. 2025. Mechanism of Drop Annunciator. Railroad Supply Company.

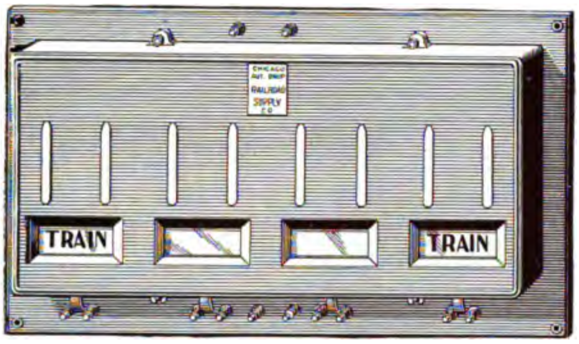


Fig. 2024. Drop Annunciator Group. Railroad Supply Company.

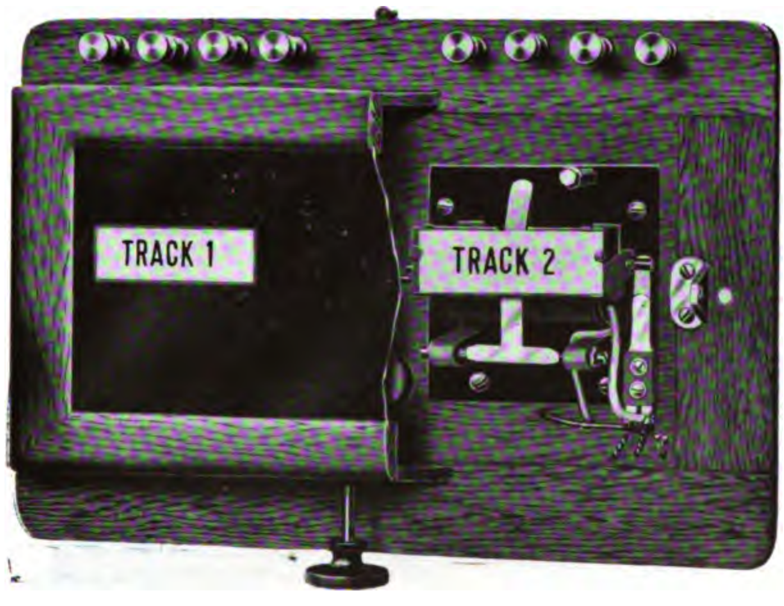


Fig. 2026. Drop Annunciator. Bryant Zinc Company.

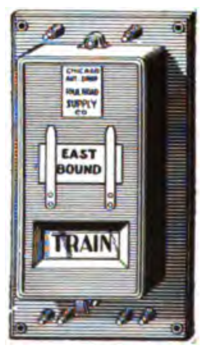


Fig. 2027. Drop Annunciator, Single Unit. Railroad Supply Company.

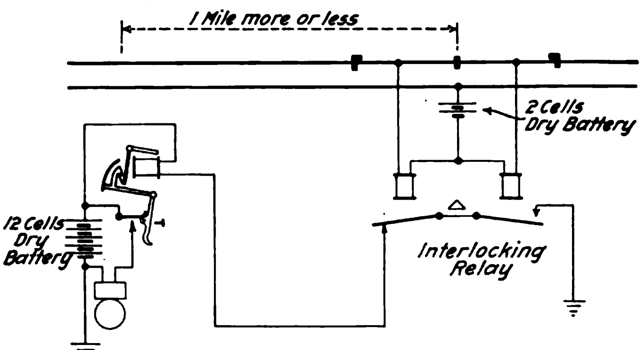


Fig. 2028. Circuit for Drop Annunciator (Figs. 2029-2030), for Use on Single Track; Automatically Announces Trains in One Direction Only; Normally Open Track Circuits. Illinois Central.

THE TRAIN DESCRIBER.

The train describer made by the Union Switch & Signal Company, shown in Figs. 2032-2033, provides 16 indications which may describe express or local passenger, freight, light engines and other classes of trains; and give directions as to what route they are to take. Also indications may be provided to convey other information such as "cancel," "repeat," etc. They are generally operated in sets consisting of one transmitter and one receiver, though one transmitter may operate two or more receivers, or one receiver may show indications from two or more transmitters. The transmitter is a make and break circuit controller driven by a key-wound spring, which is released to send a certain number of current impulses over a line to the receiver when the corresponding numbered disk is pushed. The receiver consists of a magnet operating an armature, ratchet and the pointer on the face of the instrument, the ratchet limiting the action of each impulse to a certain movement designed to rotate the pointer from one number to the next. Means are provided for manually operating the receiver, if necessary, to correspond with the transmitter by pushing the button on the lower left-hand side. Bells are usually employed in addition to the instruments shown. Fig 2020 shows Train Describers in place on a Director's Board.

Figs. 2029-2030. Iron Case Drop Annunciator. The Union Switch & Signal Company.

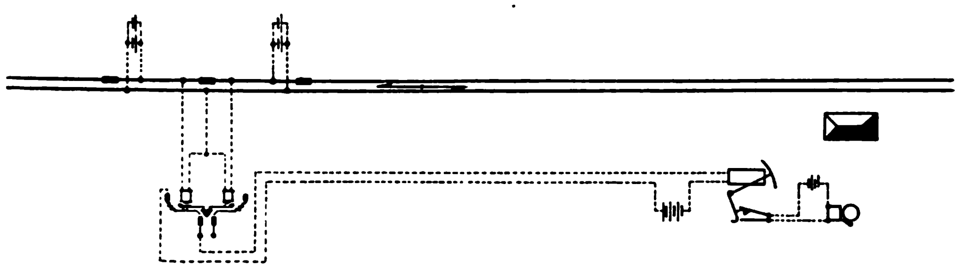


Fig. 2031. Circuit for Drop Annunciator (Figs. 2029-2030), with Interlocking Relay on Single Track; Automatically Announces Trains in One Direction Only; Normally Closed Track Circuits. The Union Switch & Signal Company.

Transmitter.

Receiver.

Figs. 2032-2033. Train Describing Instrument. The Union Switch & Signal Company.

Fig. 2034. Semaphore Indicator. General Railway Signal Company.

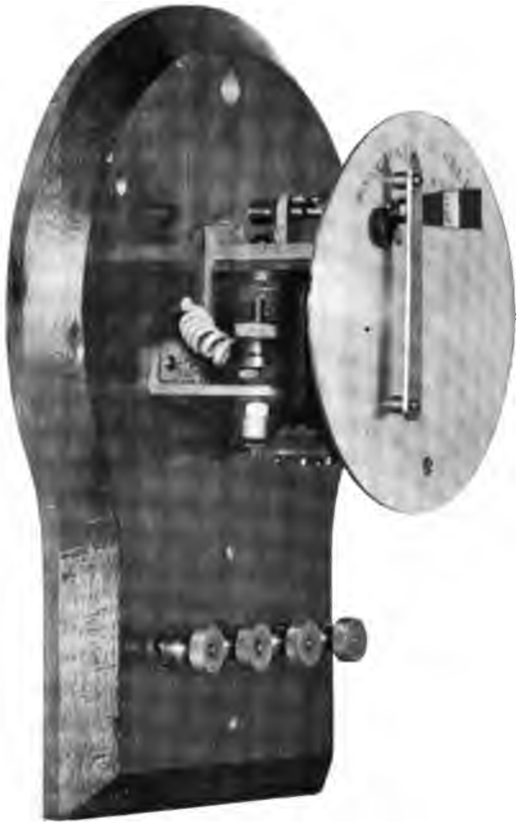
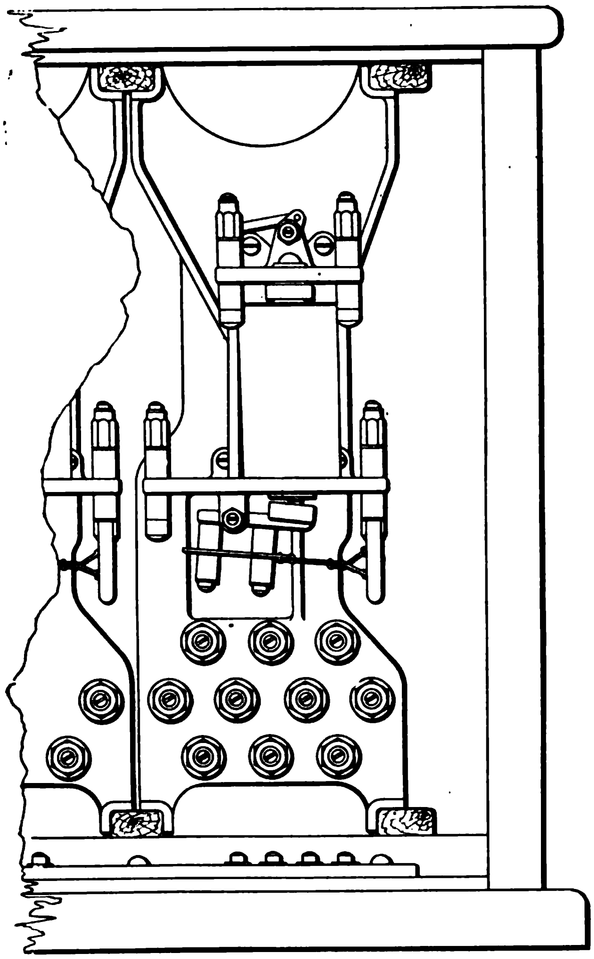


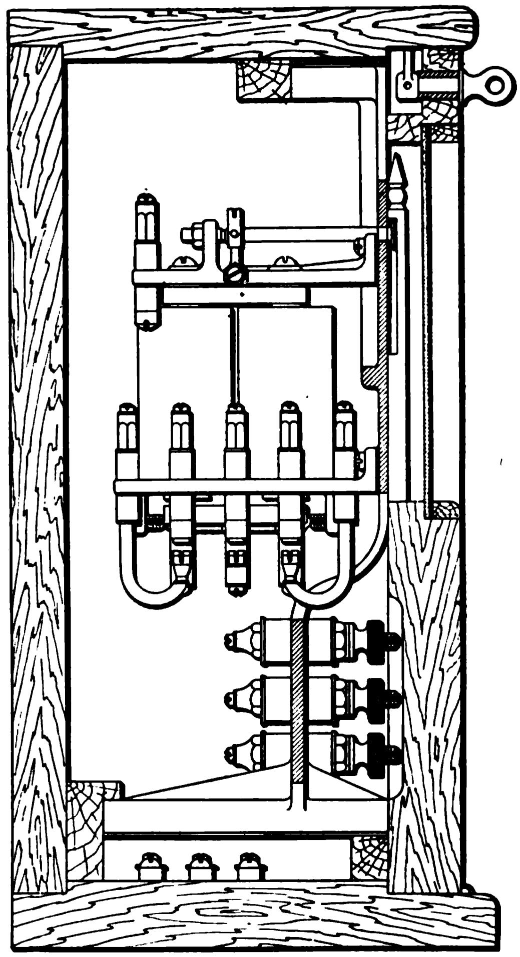
Fig. 2035. Semaphore Indicator (Fig. 2034), with Case Removed.

Fig. 2036. Iron Case Indicator, with Enclosed Pointer, Polarized Type; Constructed on the Same Principle as the Switch Indicator Shown in Figs. 2855-2857. The Union Switch & Signal Company.

Fig. 2037. Iron Case Semaphore Indicator, Neutral Type. The Union Switch & Signal Company.



Rear View of Single Unit.



Side View Showing Arrangement of Coils and Contacts.

Figs. 2038-2039. Multiple Unit Indicator with Wooden Case (See Fig. 2019). The Union Switch & Signal Company.

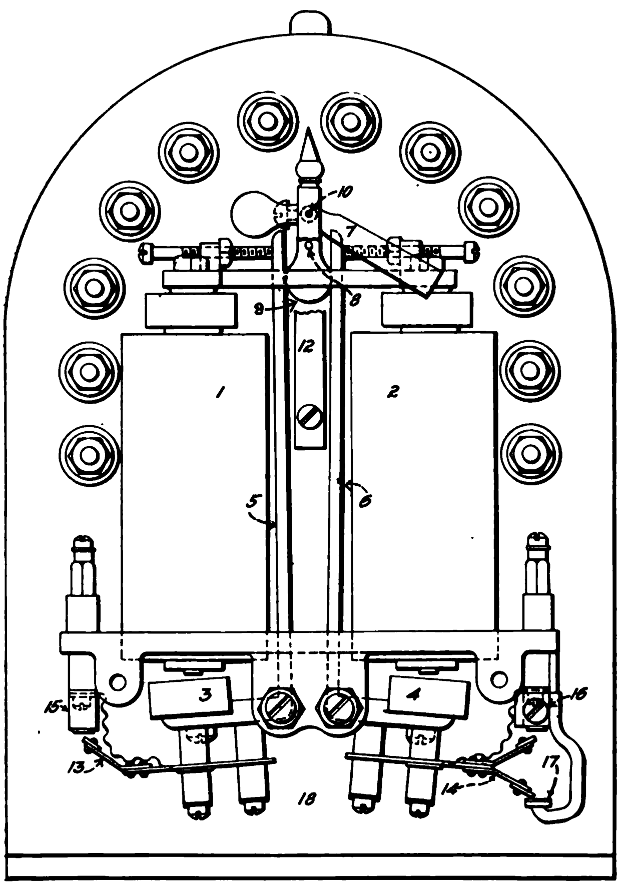
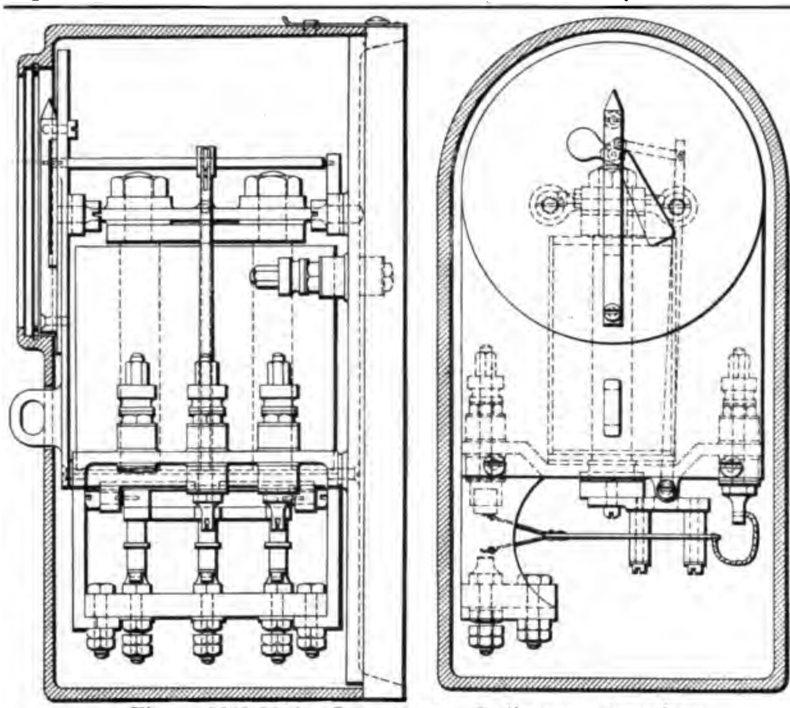


Fig. 2040. Three-Position Signal Repeater. Federal Signal Company.

Fig. 2041. Disk Indicator Mechanism. Railroad Supply Company.

Fig. 2042. Disk Indicator Complete. Railroad Supply Company.

The three-position signal repeater, shown in Fig. 2040, consists of two magnets, 1-2, and their armatures, 3-4. These armatures are connected with levers 5 and 6, which move the miniature semaphore 7 to the clear or stop position by striking pin 8 on counterweight 9, secured to shaft 10, on which is mounted the semaphore arm 7. Connected to armatures 3-4 are contact figures 13-14. Front contacts 15 and 16, and, if required, back contacts 17 are provided. Binding posts are mounted on the back of the frame 18. A cover with glass front is placed over the mechanism. The operation of the repeater is as follows: A circuit controller on the signal closes the circuit through magnet when the signal assumes the stop position. This throws miniature semaphore arm to the corresponding stop position by lever 5 striking pin 8. When the signal assumes the proceed position, circuit through magnet 1 is broken, circuit through magnet 2 is closed and the arm is moved to the clear position by lever 6. The controller on the signal is so arranged that when the signal arm is 15 degrees below stop, or 15 degrees above proceed position, neither magnet 1 or 2 is energized and the arm will assume a middle position, as shown in the figure, owing to the counterweight 9 swinging into a vertical position. The back and front contacts can be used for making or breaking circuits.



Figs. 2043-2044. Semaphore Indicator. American Railway Signal Company.

Fig. 2045. Semaphore Indicator. Railroad Supply Company.

*Figs. 2046-2049. Types of Electric Bells Used with Annunciators and Indicators or Separately.

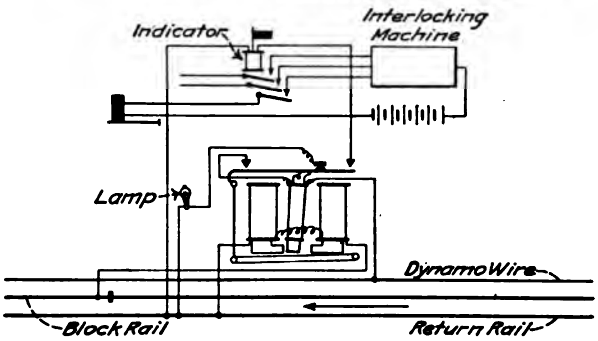


Fig. 2050. Circuits for Block Indicator and Signal at Interlocking Plant. Boston Elevated Railroad.

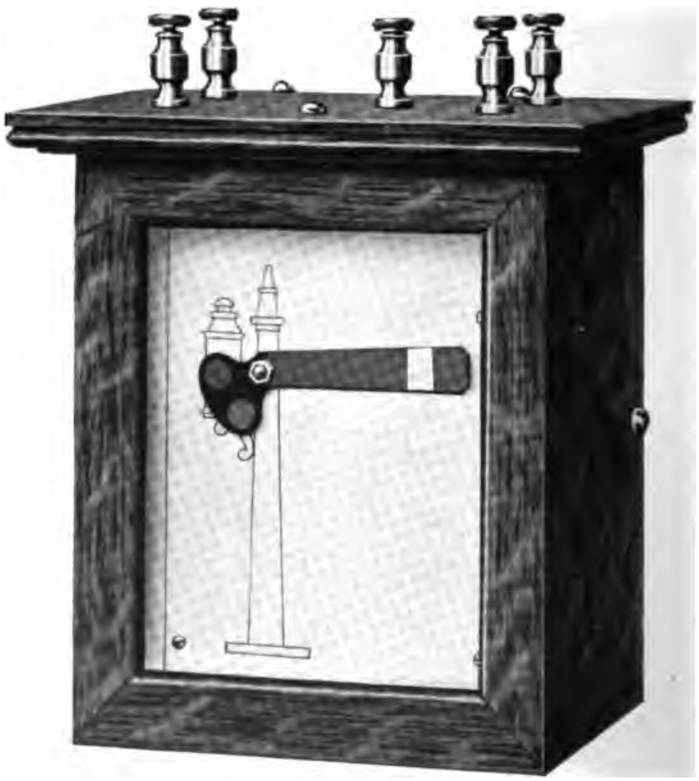
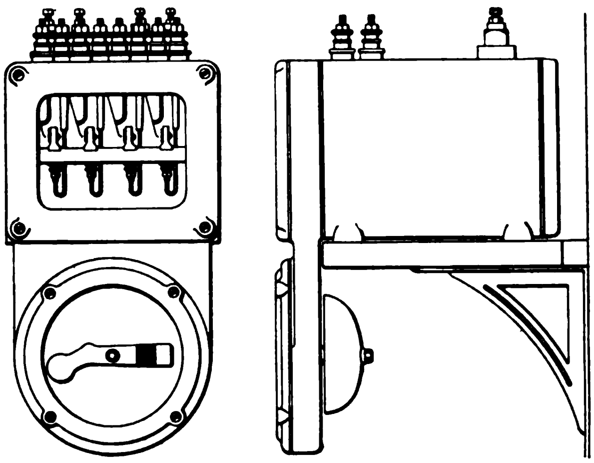


Fig. 2051. Semaphore Indicator. Bryant Zinc Company.



Figs. 2052-2053. Alternating Current Semaphore Indicator. General Railway Signal Company.

Figs. 2052-2053 illustrate an alternating current tower indicator with bell, made by the General Railway Signal Co. It is constructed like the switch indicator shown in Figs. 2843-2844, except that the semaphore arm is below the mechanism instead of above. It is designed to be mounted on a shelf.

Names of Parts, Fig. 2054.

A *Track Batteries*
B *Line and Bell Battery*
E *Interlocking Relay*
F *Annunciator Drop*
G *Bell*

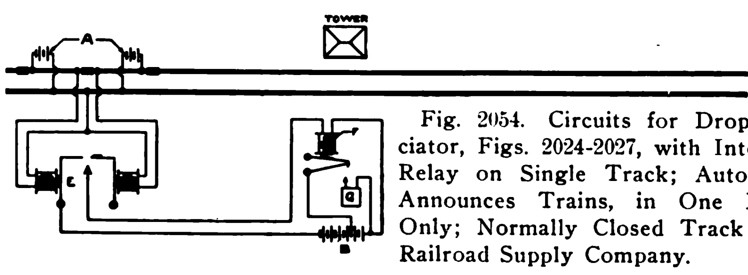


Fig. 2054. Circuits for Drop Annunciator, Figs. 2024-2027, with Interlocking Relay on Single Track; Automatically Announces Trains, in One Direction Only; Normally Closed Track Circuits. Railroad Supply Company.

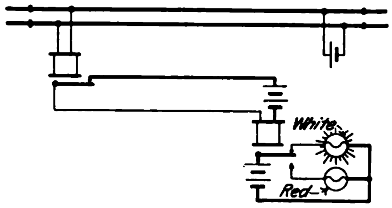


Fig. 2055. Simple Circuit for Track Indicator.

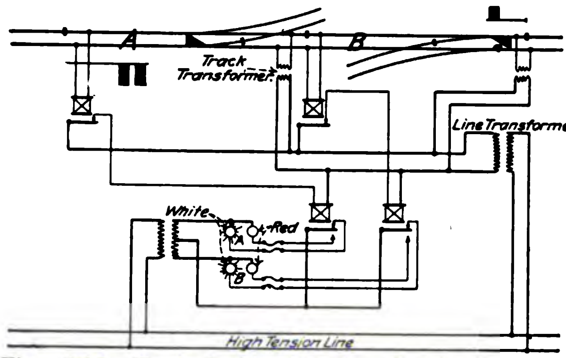


Fig. 2056. Typical Circuits for Track Indicator Operated by Alternating Current. General Railway Signal Company.

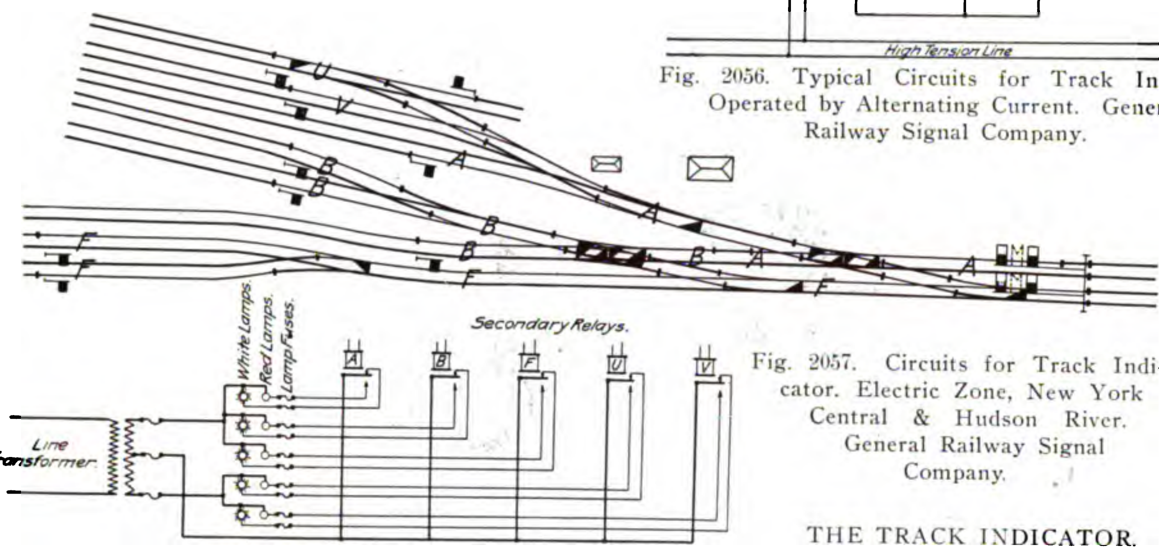


Fig. 2057. Circuits for Track Indicator. Electric Zone, New York Central & Hudson River. General Railway Signal Company.

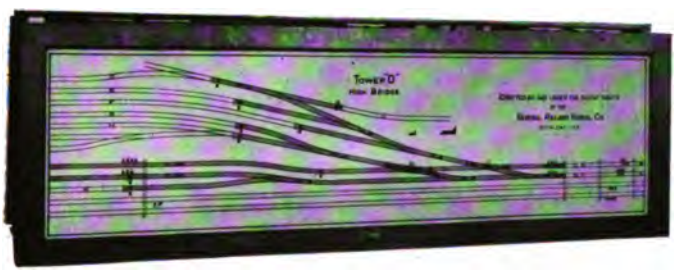


Fig. 2058. Track Indicator Illuminated by Electric Lights. General Railway Signal Company.

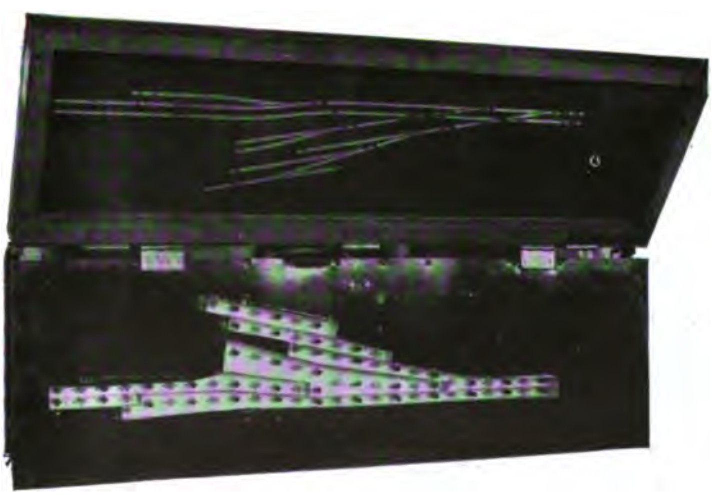


Fig. 2059. Track Indicator Shown in Fig. 2058, with Glass Front Raised, Showing Arrangement of Lamps and Channels.

THE TRACK INDICATOR.

Figs. 2055-2059 illustrate a track indicator illuminated by electric lights and typical circuits for operating same. The indicator consists of a box, the cover of which contains a glass plate painted to show a diagram of the tracks, switches and signals concerned. The part representing the sections covered by the track indicator is transparent, the rest being opaque. Within the box are rows of electric lights corresponding to the transparent track sections on the glass. Each row of lights is enclosed in a small channel so that the light can shine only at right angles to the back of the box, and each row is divided to correspond with the track circuit sections. The lights are alternately red and white. When a track section is unoccupied the white lights burn; the presence of a train extinguishes them and causes the red lights to burn, so that the signalman is kept constantly informed of the conditions of the track sections at his plant. The apparatus illustrated was made by the General Railway Signal Company and installed on the Electric Zone of the New York Central & Hudson River.

Figs. 2060, 2062 illustrate a track indicator designed by the Union Switch & Signal Company and installed in connection with the automatic block signals in the East River tunnel of the Interborough Rapid Transit Company. As will be seen from a comparison of the circuit diagrams, it is operated in the same manner as the indicator illustrated in Figs. 2056-2059, the principal difference being that green lamps are used instead of white to indicate that the track is unoccupied.

Fig. 2061 shows an illuminated indicator attached to the levers of an electro-pneumatic interlocking machine, which shows when the track section in which the function occurs is occupied by a train. This is accomplished by an electric light behind a ground glass beneath each lever. When the track section is unoccupied the light burns.

THE LAMP INDICATOR.

Figs. 2063-2064 show the circuits and apparatus used by the Great Western Railway of England, to indicate to a signalman whether or not the signal lamps are lighted. In the illustration two thermostats A are shown, one for each of two lamps. The thermostat consists of a spiral of readily expanding metal B, connected electrically to the battery S. The other side of the battery is connected to ground. When the lamp is lighted the spiral B expands and makes contact at C, completing the circuit from battery S, through the thermostat controller, coil of the indicator, coils of the relay to ground (terminal N), back to battery. This energizes the indicator and the pointer H moves the banner K so as to show "In" at an opening in the cover (not shown). If one of the lamps is extinguished its thermostat opens the circuit and de-energizes the indicator, causing the banner to display "Out." The indicator is constructed similar to the block indicator shown in Fig. 238, and operates in the same manner. F is a relay controlling the bell D. The adjustable stops L on the indicator limit the travel of H.

A local circuit is operated by the back contact on the relay F to ring the bell in case any lamp should go out. In the daytime, when the lamps are not needed, the bell circuit is cut out by the switch shown just beneath the lightning arrester. Fig. 2063 shows how one bell may be used with a number of indicators.

Fig. 2060. Illuminated Track Indicator and Operator's Desk. Interborough Rapid Transit Company.

Fig. 2061. Electro-Pneumatic Interlocking Machine, with Illuminated Indicators Beneath Levers. Delaware, Lackawanna & Western. The Union Switch & Signal Company.

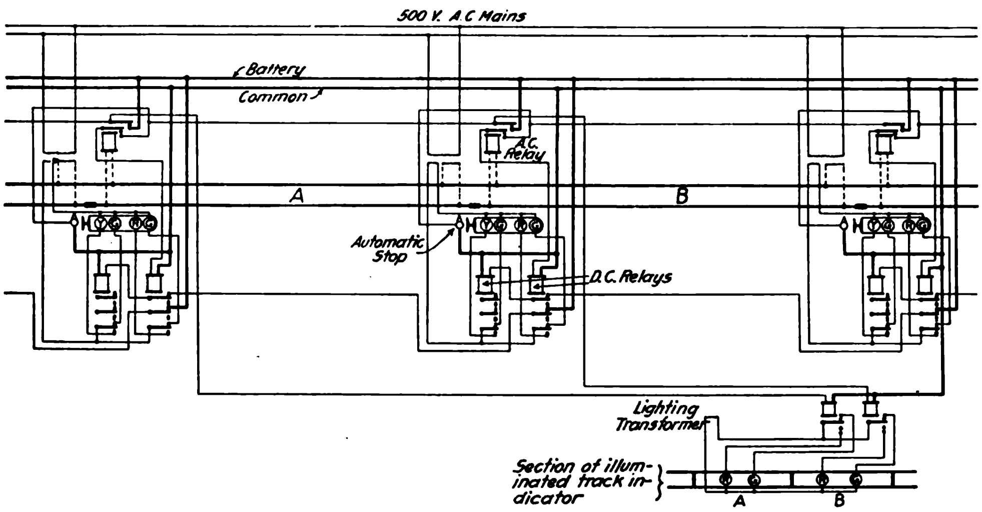


Fig. 2062. Typical Arrangement of Circuits, East River Tunnels, Showing Circuits Controlling Track Indicator, Fig. 2060.

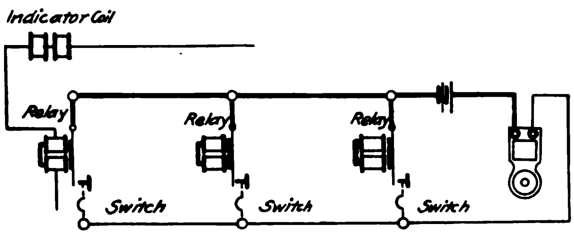


Fig. 2063. Arrangement of Circuits for Operating One Bell from Several Lamp Indicators.

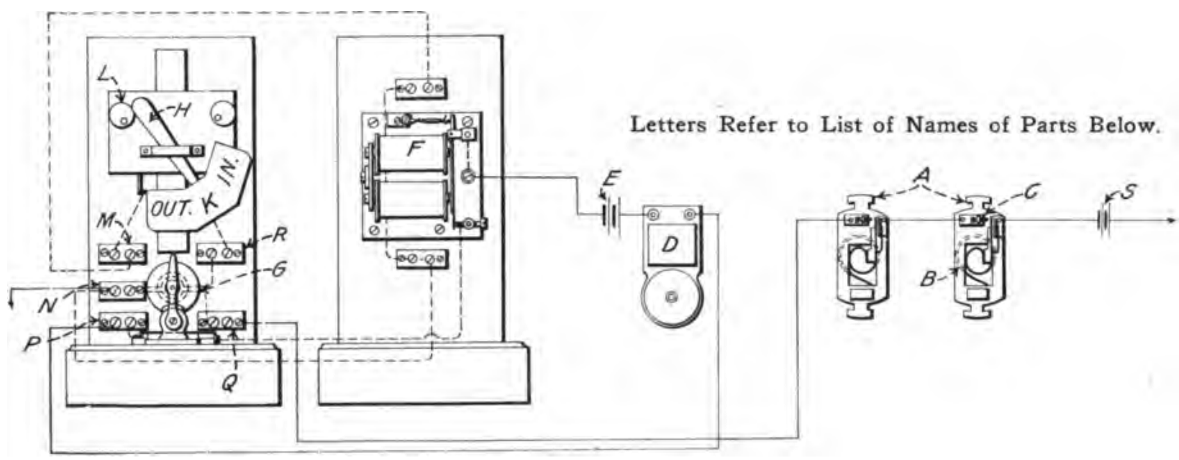
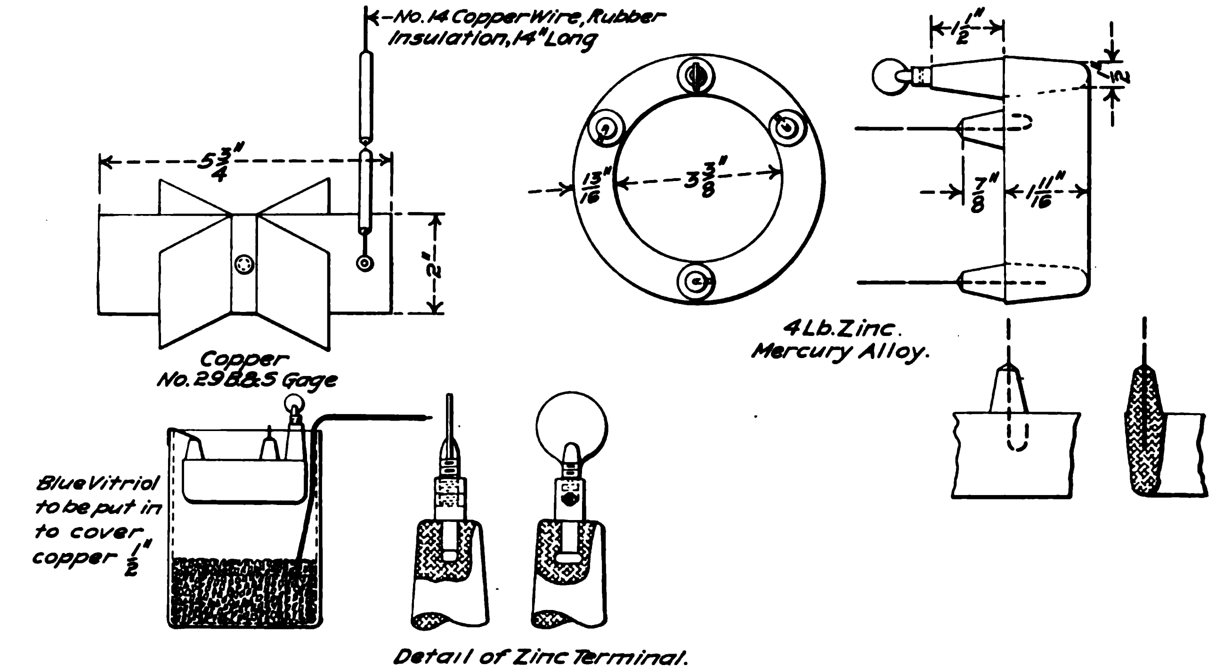


Fig. 2064. One Indicator Connect.d to Operate with Two Lamps.

Figs. 2063-2064. Circuits for Lamp Indicators. Great Western Railway of England.

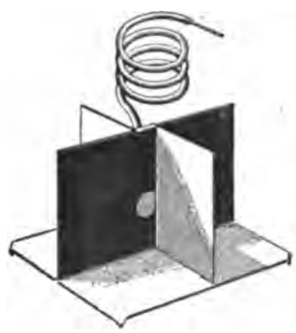
Names of Parts of Apparatus for Lamp Indicator; Fig. 2064.

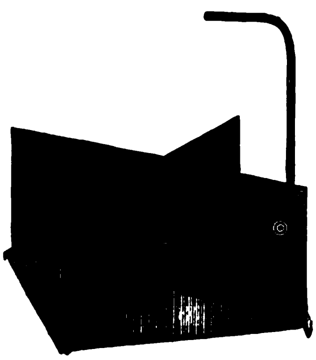
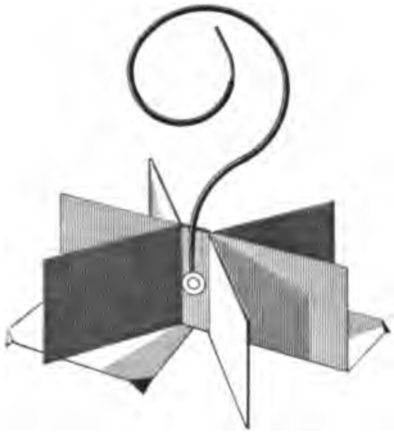
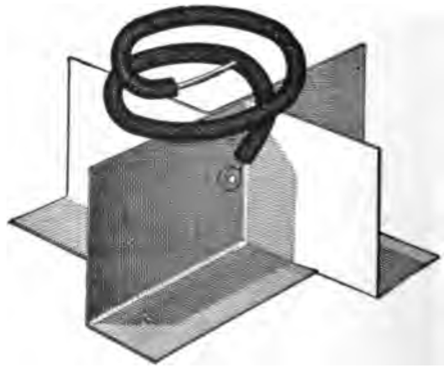
A	*Thermostat Circuit Controllers*	**K**	*Banner*
B	*Expanding Spiral*	**L**	*Adjustable Stop*
C	*Contact Post*	**M**	*Coil Terminal*
D	*Bell*	**N**	*Ground Terminal*
E	*Bell Battery*	**P**	*Bell Circuit Terminal*
F	*Relay*	**Q**	*Line Terminal*
G	*Spool Lightning Arrester*	**R**	*Coil Terminal*
H	*Pointer*	**S**	*Line Battery*



Figs. 2065-2072. Gravity Battery Details. New York Central & Hudson River.

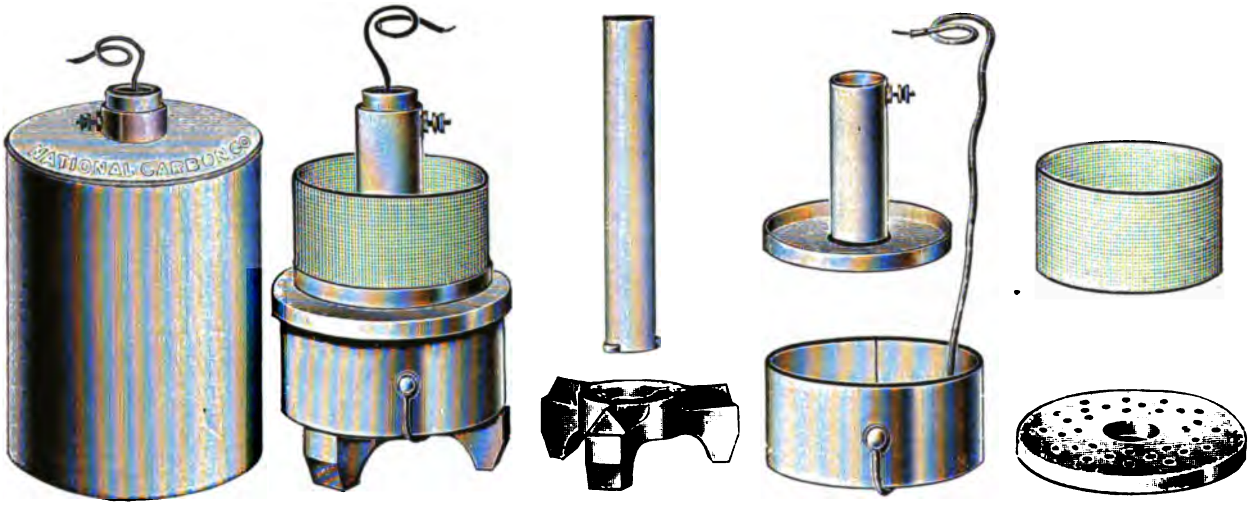
*Figs. 2073-2075. Types of Gravity Battery Zincs.



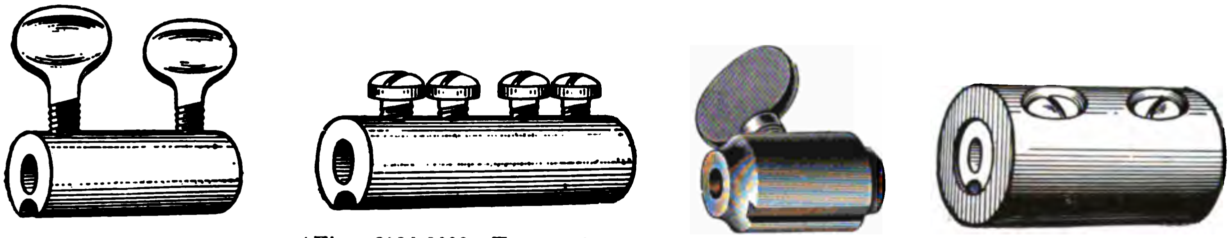




*Figs. 2076-2080. Types of Gravity Battery Coppers.

Figs. 2081-2087. "Gordon" Primary Battery Cell and Details. Gordon Battery Company.



Figs. 2088-2095. "Columbia" Primary Cell and Details. National Carbon Company.



*Figs. 2096-2099. Types of Battery and Wire Connectors.

Fig. 2100. Battery Connector Soldered to Wire. New York Central & Hudson River.

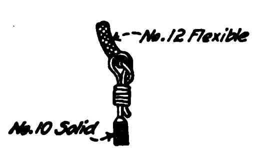


Fig. 2101. Joint Between Solid and Flexible Wire, for Use at Battery Chutes. Southern Pacific-Union Pacific.

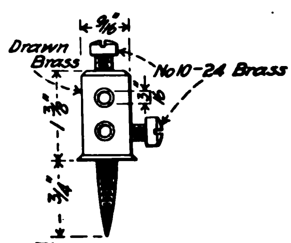
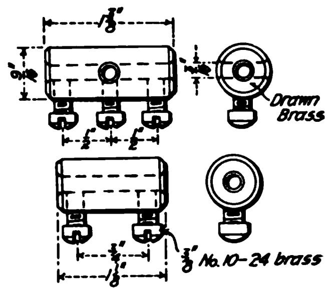
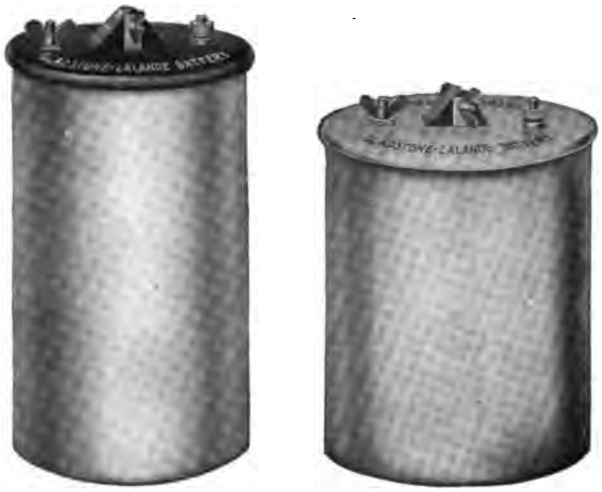
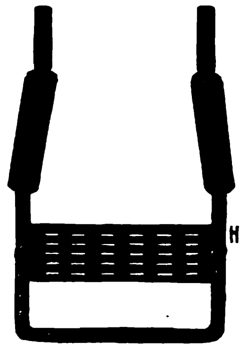


Fig. 2102. Binding Post for Copper Terminal of Gravity Battery. Southern Pacific-Union Pacific.

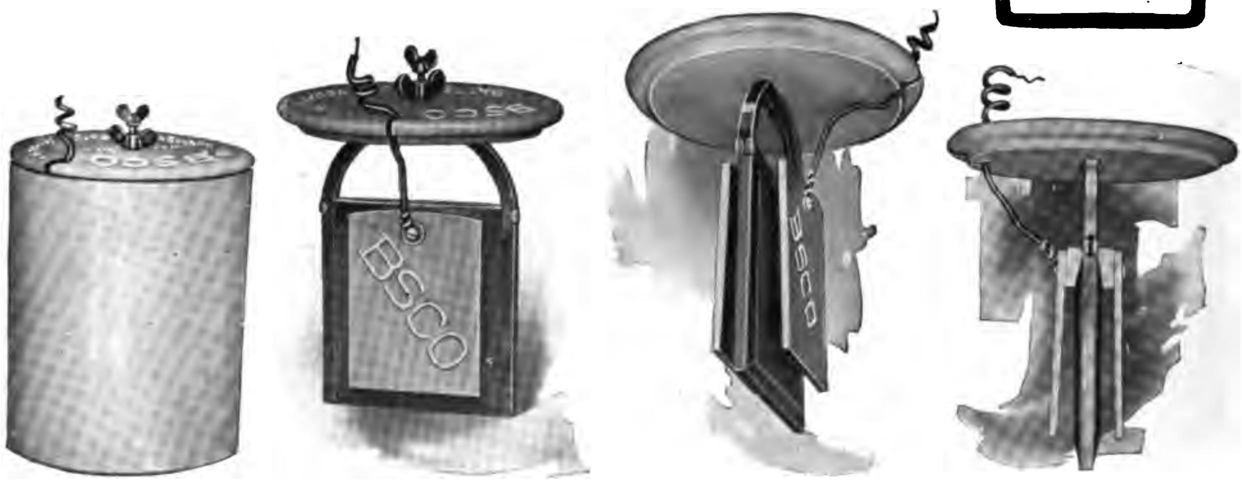


Figs. 2103-2106. Battery Wire Connectors. Southern Pacific-Union Pacific.



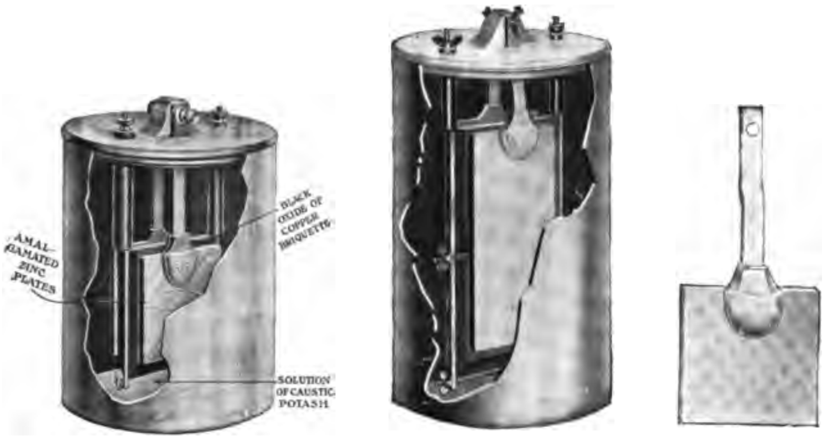


Figs. 2107-2112. "Gladstone" Primary Battery Cells and Details. Battery Supplies Company.



Figs. 2113-2116. "BSCO" Primary Battery Cell and Details. Battery Supplies Company.

Figs. 2117-2120. "Waterbury" Primary Battery Cell and Details. Waterbury Battery Company.



Figs. 2121-2123. "Edison" Primary Battery Cells and Zinc Plate. Edison Manufacturing Company.

Fig. 2124. "Banks" Primary Battery Cell. Banks Electric & Manufacturing Company.

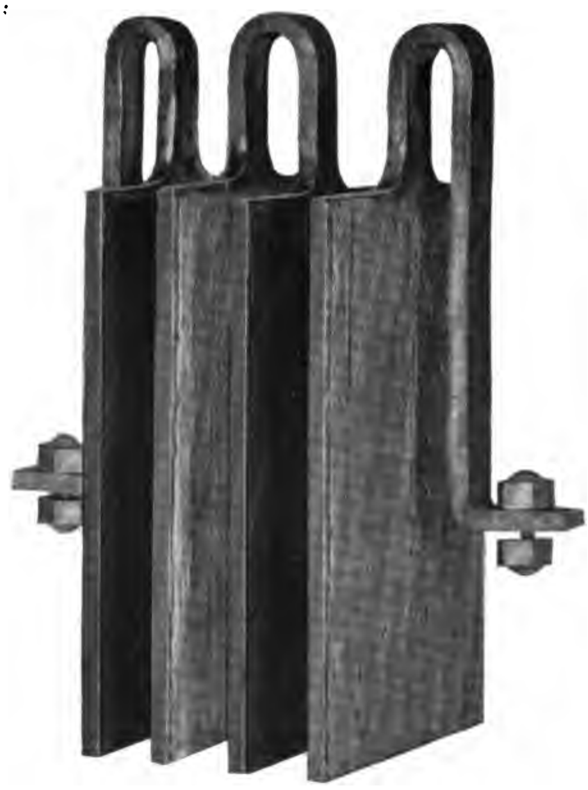


Fig. 2125. Storage Battery Plates for Two-Plate Cells. Westinghouse Machine Company.

Fig. 2126. Two-Plate Storage Cells. Westinghouse Machine Company.

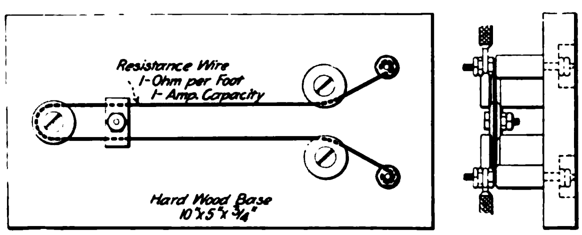


Fig. 2127. Adjustable Resistance for Storage Battery When Used on Track Circuits. Chicago, Milwaukee & St. Paul.

Fig. 2128. Storage Battery Cell Complete. Westinghouse Machine Company.

Figs. 2129-2130. Positive Storage Battery Plate. Westinghouse Machine Company.

Figs. 2131-2132. Storage Battery Elements for Use in Portable Sets (See Figs. 2137-2140). Westinghouse Machine Company.

Positive.

Negative.

Figs. 2133-2136. Storage Battery Details (from Left to Right); Positive Plates, Glass Tube Separators, Glass Jar in Glass Sand Tray, Negative Plates. Westinghouse Machine Company.

Fig. 2137. Large Portable Storage Battery in Case. Westinghouse Machine Company.

Fig. 2138. Portable Storage Battery Cell. Westinghouse Machine Company.

Fig. 2139. Portable Storage Battery in Case. Westinghouse Machine Company.

Fig. 2140. Details of Hard Rubber Jar and Separators for Portable Sets. Westinghouse Machine Company.

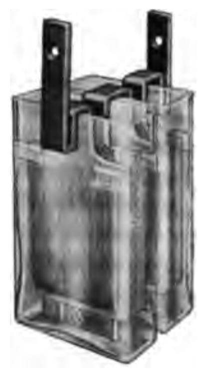


Fig. 2143. Type "W" Couples. Gould Storage Battery Company.

Fig. 2141. Type "M" Positive Element. Gould Storage Battery Company.

Fig. 2142. Type "M" Cell Complete. Gould Storage Battery Company.

Fig. 2144. Type "W. S." Couples. Gould Storage Battery Company.

Fig. 2145. Group of Negative Plates.

Fig. 2146. Group of Positive Plates.

Fig. 2147. Cell Complete.

Fig. 2148. Two-Plate Cell; Small Capacity.

Fig. 2149. Two-Plate Type.

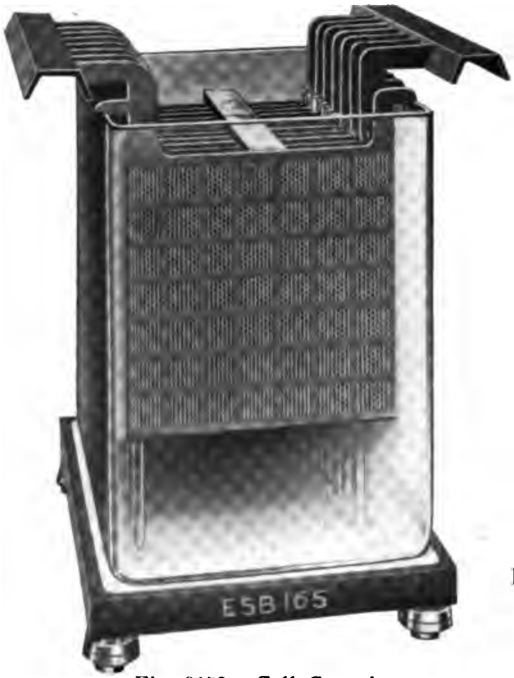
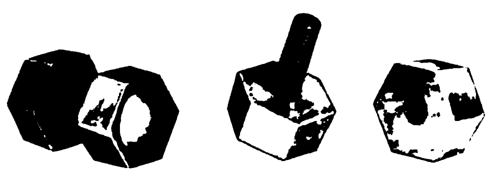


Fig. 2152. Cell Complete.

Fig. 2151. Special Portable Type. Union Pacific-Southern Pacific.

Fig. 2153. Standard Portable Type.

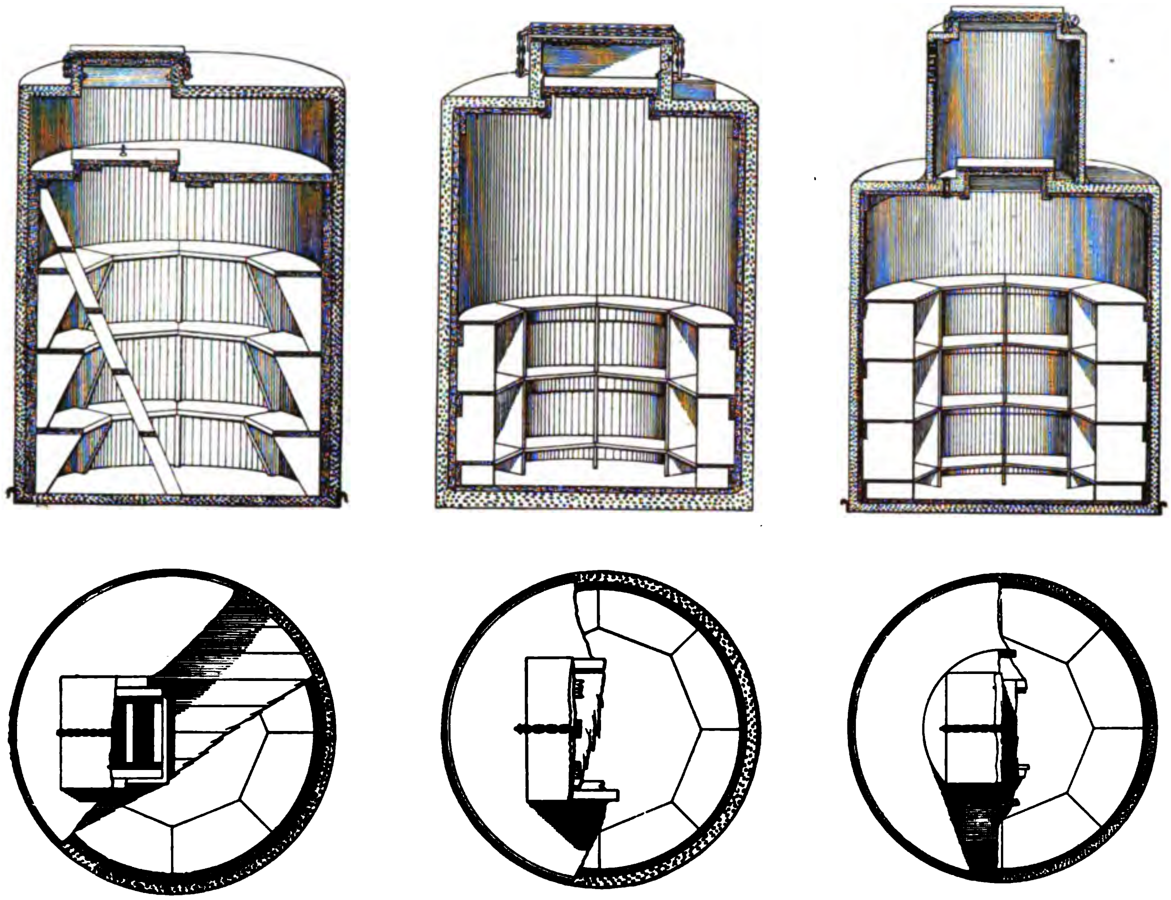
Fig. 2150. Sand Tray.



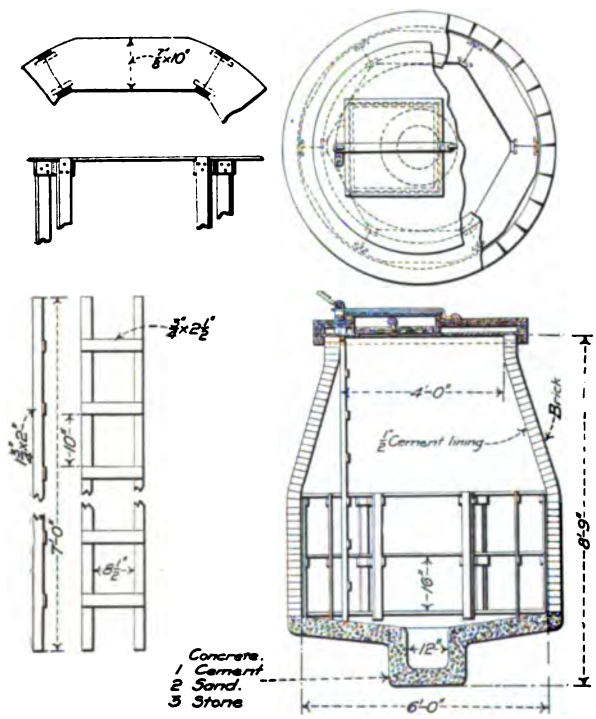
Figs. 2154-2156. Bolt Connectors.

Fig. 2159. Wood Separator.

Figs. 2145-2159. "Chloride Accumulator" Storage Battery Cells and Details. Electric Storage Battery Company.



Figs. 2160-2165. Hydrolithic-Concrete Battery Wells. E. J. Winslow Company.



Figs. 2166-2170. Brick Battery Well. New York Central & Hudson River.

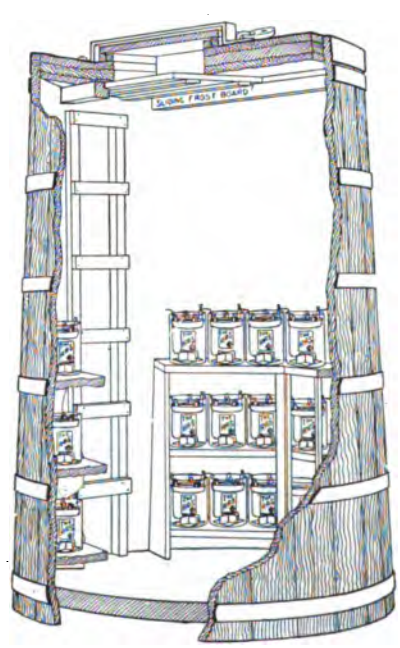
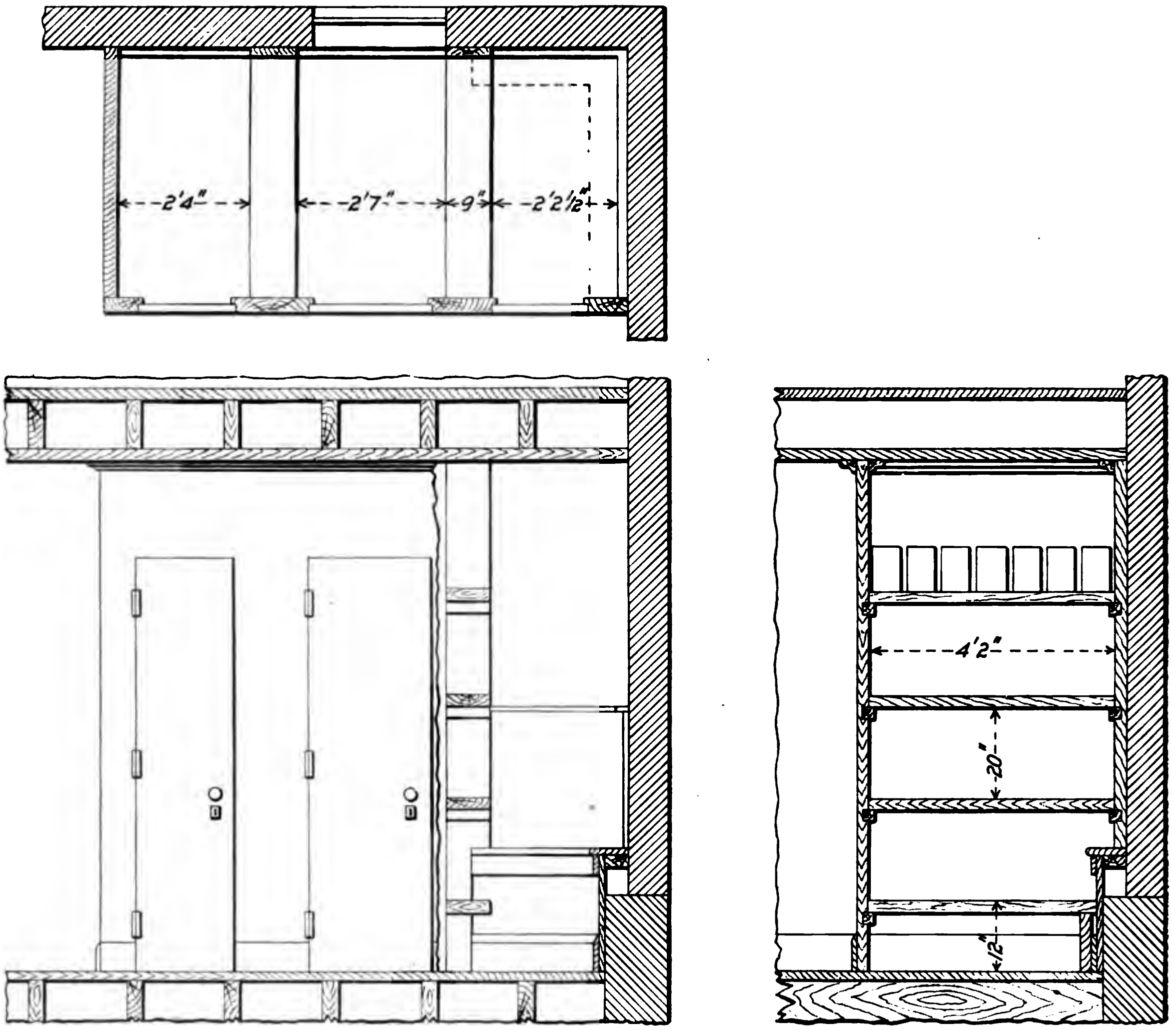
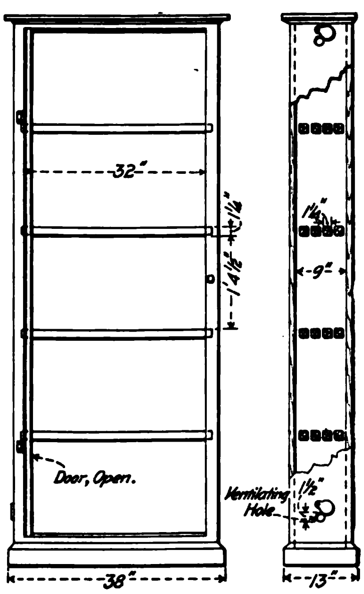


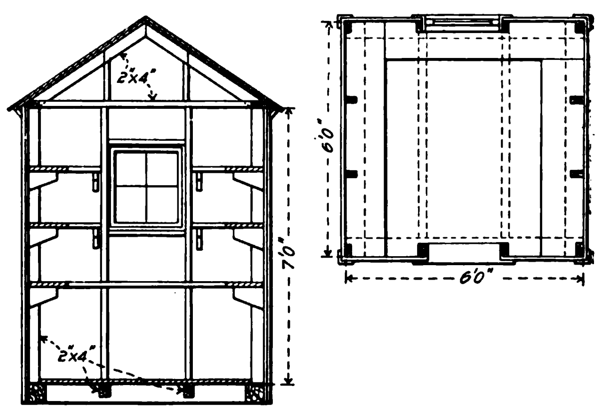
Fig. 2171. Wooden Battery Well. Railroad Supply Company.



Figs. 2172-2174. Storage Battery Cupboard for Signal Tower. General Railway Signal Company.

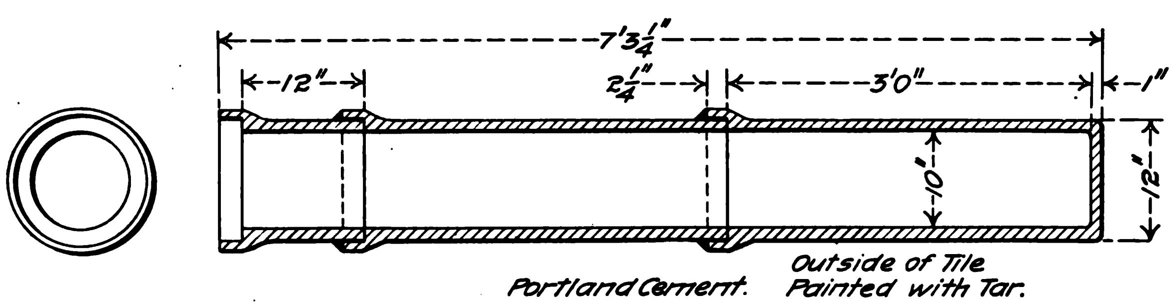


Figs. 2175-2176. Battery Cupboard. Michigan Central.

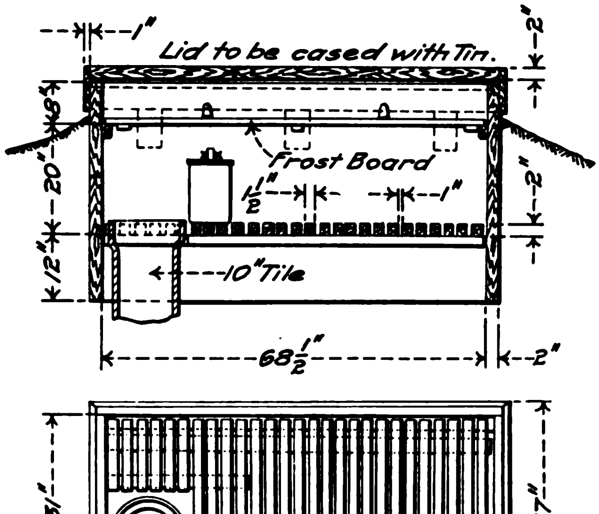


Figs. 2177-2178. Battery House. Michigan Central.

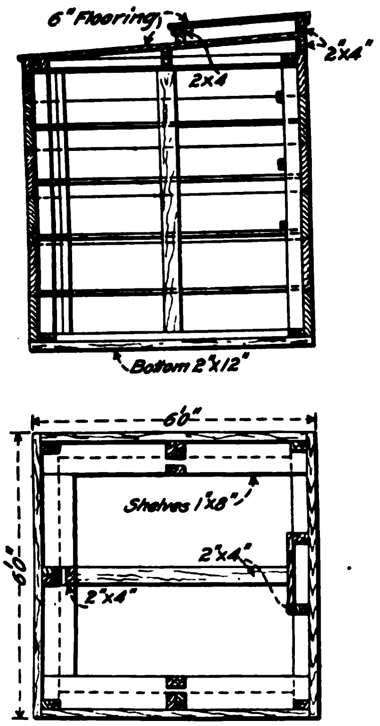
Figs. 2179-2183. Iron Battery Box and Details. Railroad Supply Company.



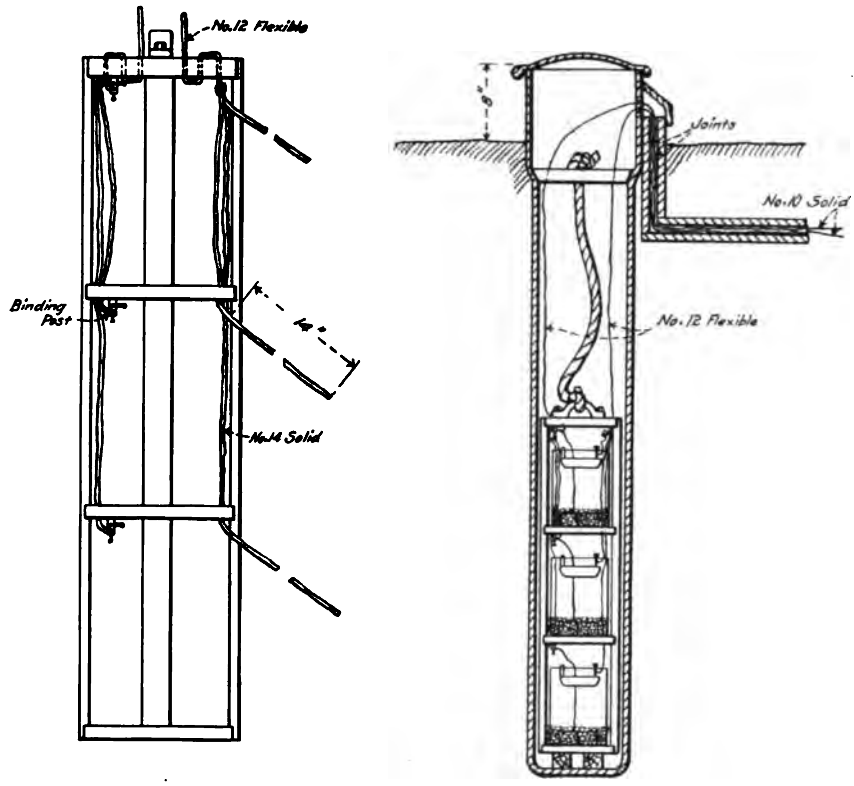
Figs. 2184-2185. Tile Battery Chute. Michigan Central.



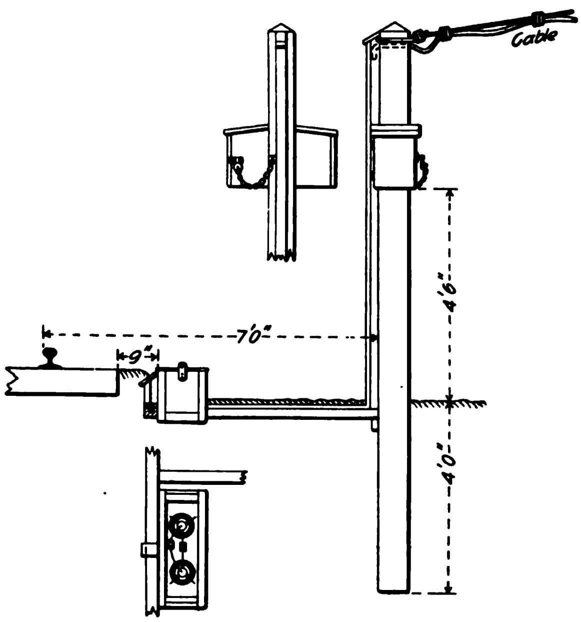
Figs. 2186-2187. Battery Box and Chute. Michigan Central.



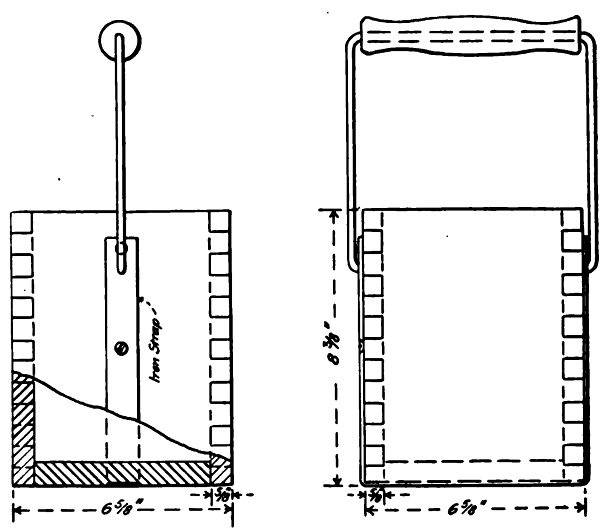
Figs. 2188-2189. Wooden Battery Cellar. Chicago & North-Western.



Figs. 2190-2191. Elevator and Standard Arrangement of Cells in Battery Chute. Southern Pacific-Union Pacific.



Figs. 2192-2194. Relay Box, Post and Wooden Gravity Battery Box; Cable Connection to Pole Line. Southern Pacific-Union Pacific.



Figs. 2195-2196. Portable Storage Battery Case. Southern Pacific-Union Pacific.

Fig. 2197. Single Cast Iron Battery Chute in Place. Railroad Supply Company.

Fig. 2198. Single Cast Iron Battery Chute. Bryant Zinc Company.

Fig. 2199. Single Cast Iron Battery Chute. Railroad Supply Company.

Fig. 2200. Double Cast Iron Battery Chute. Railroad Supply Company.

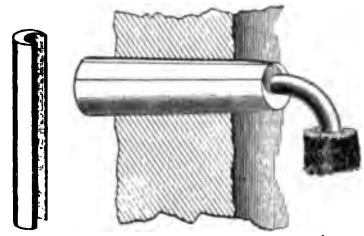
*Fig. 2201. Bond Wires in Bundle.

Fig. 2202. Machine Fitted to Drill Base of Rail.

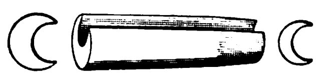
Fig. 2203. Machine Fitted to Drill Web of Rail.

Figs. 2202-2203. Drilling Machine for Rail Bonding. The Union Switch & Signal Company.

*Fig. 2204. Self-Feeding Drilling Machine.



Figs. 2206-2207. "Boot Leg" Channel Pin and Bond Wire in Rail. Railroad Supply Company.



Figs. 2208-2210. Channel Pin.

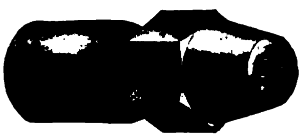
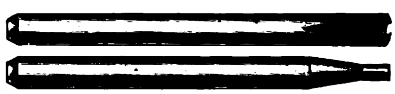
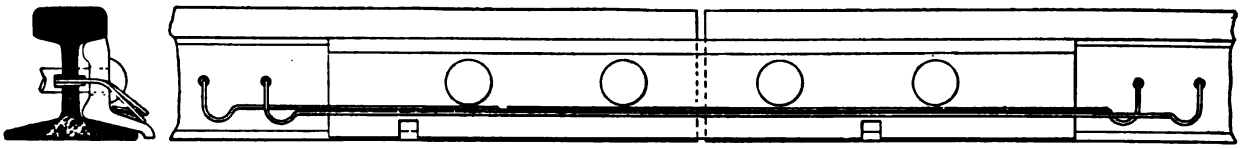


Fig. 2205. Chuck for Drilling Machine. Railroad Supply Company.



Figs. 2211-2212. Channel Pin Set and Punch. Bryant Zinc Company.

Fig. 2213. Twist Drill for Bonding. Bryant Zinc Company



Figs. 2214-2215. Bond Wires Outside of Splice Bars; Fastened by Bonding Tubes.

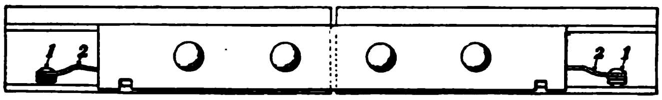


Fig. 2216. Bond Wire Behind Splice Bar; Fastened by Rivets.

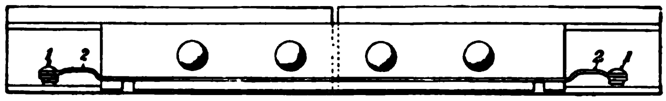


Fig. 2217. Bond Wire Outside of Splice Bar; Fastened by Rivets.

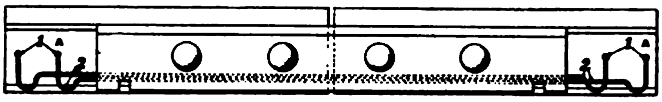


Fig. 2218. Bond Wires Behind Splice Bar; Fastened by Channel Pins.

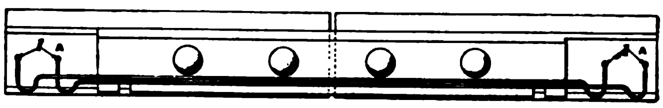
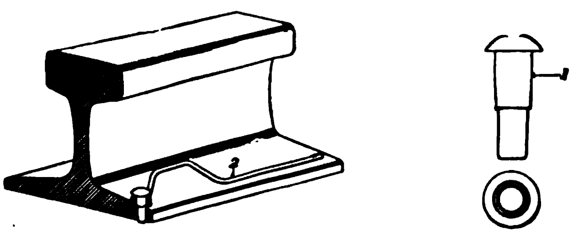
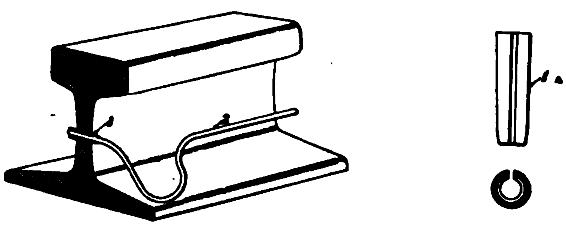


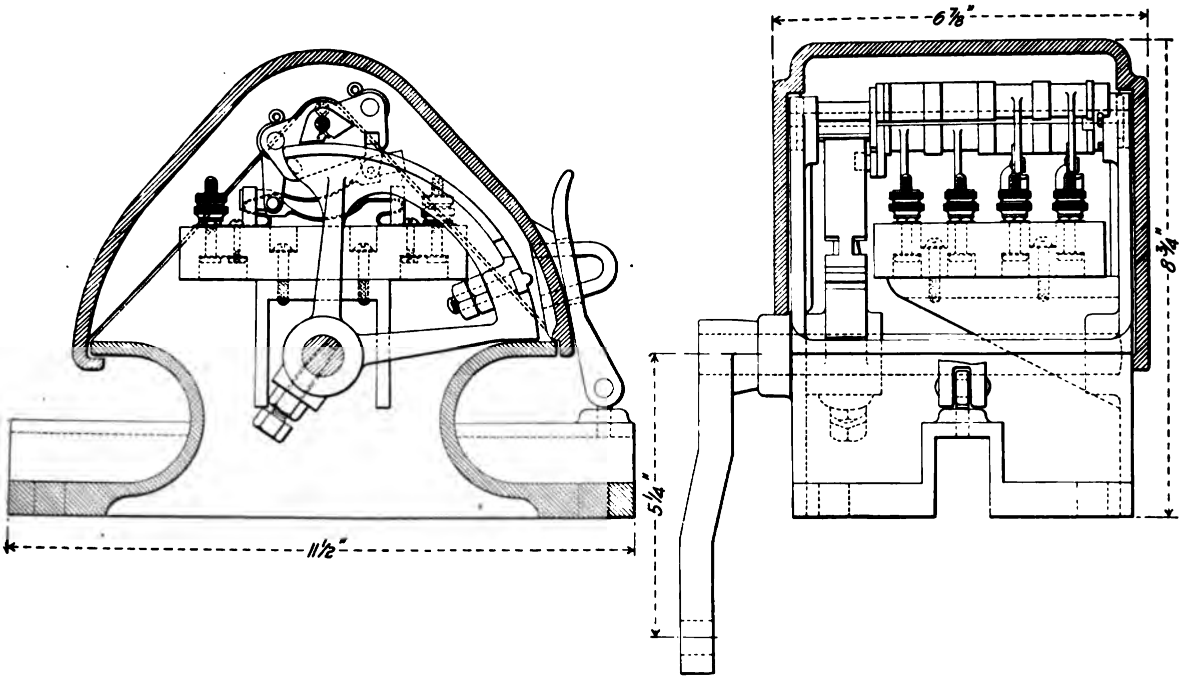
Fig. 2219. Bond Wires Outside of Splice Bar; Fastened by Channel Pins.



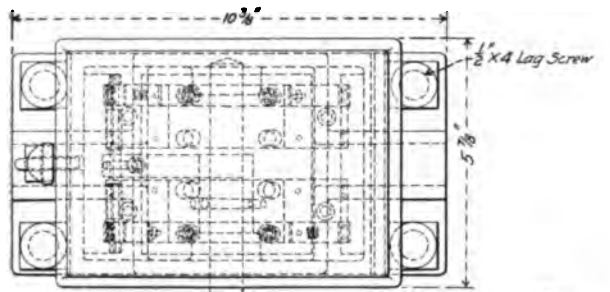
Figs. 2220-2222. Bonding Rivet and Section of Rail Showing Application. The Union Switch & Signal Company.



Figs. 2223-2225. Bonding Tube and Section of Rail Showing Application. The Union Switch & Signal Company.

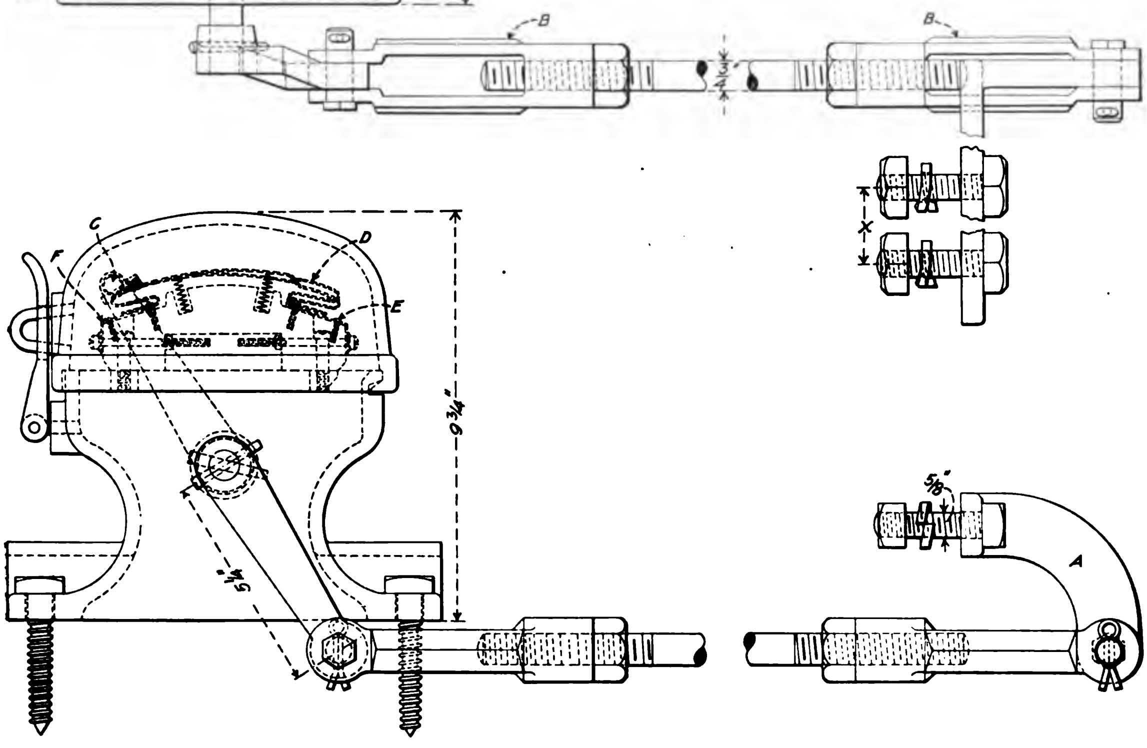


Figs. 2226-2227. Style "E" Switch Box. Hall Signal Company.



Names of Parts of the Hall Style "C" Switch Box; Figs. 2228-2229.

A *Switch Point Lug*
B *Screw Jaw*
C *Lignum Vitae Roller*
D *Contact Spring, with Platinum Contact*
E *Spring Anvil, with Platinum Contact*
F *Heel of Contact Spring*



Figs. 2228-2229. Style "C" Switch Box. Hall Signal Company.

Figs. 2230-2231 show the vertical rotary switchbox, Model 2, made by The Union Switch & Signal Company, a style generally used in automatic block signaling. The box is usually fixed to a tie, about 3 ft. from the track. The movement of the switch points closes contacts in the box which connect the opposite rails of the track, so as to de-energize the track relay, and thus throw to the stop position the home signal for that section, as in Fig. 355. Contacts may also be arranged to break the control circuits for signals when the switch is open. The driving or connecting rod is fastened to the switch rail by a lug bolted close to the point on the normally closed side. Adjustment is provided so that the opening of the switch point, as much as ¼ in., will operate the circuit controllers in the box. The wires are brought into the box through a hole in the tie to binding posts connected with the contact springs which are guided by a crosspiece. The crosspiece is operated to move the springs by a roller engaging a cam revolved by a shaft. The shaft is turned by a crank driven by the connecting rod. There is a large lug on the bottom of the case which is set into the tie as shown, holding the box in place.

Figs. 2230-2231. Vertical Rotary Switchbox, Model 2. The Union Switch & Signal Company.

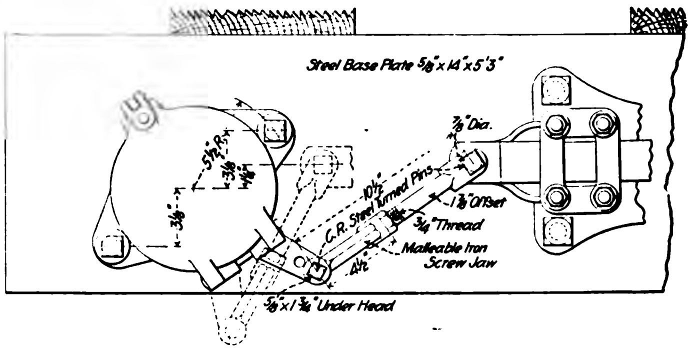
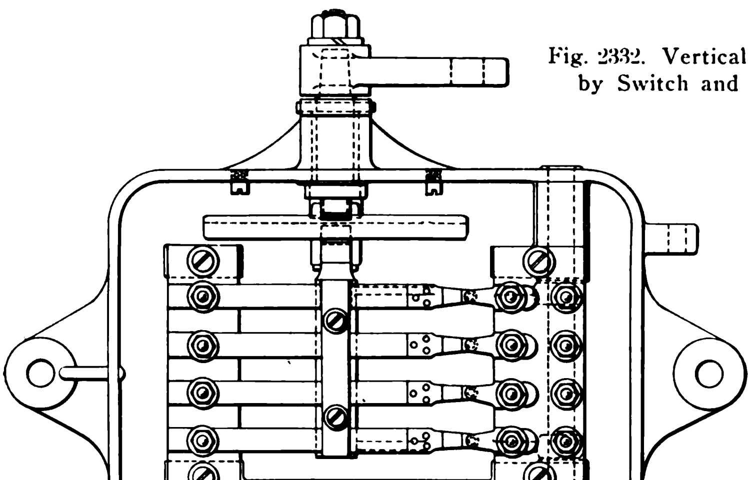
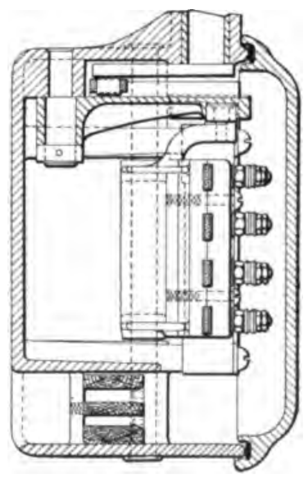
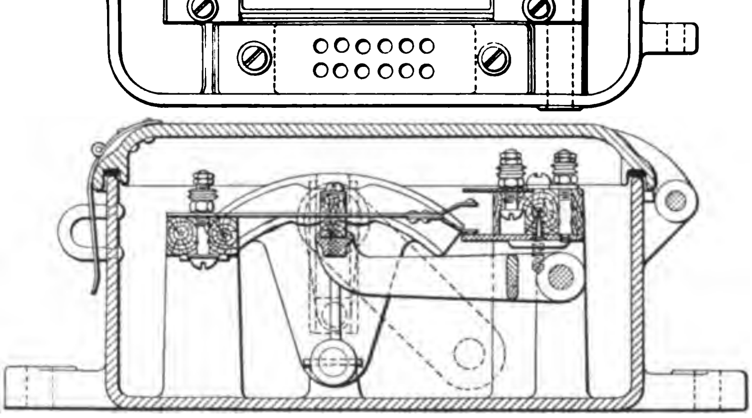


Fig. 2332. Vertical Rotary Switchbox, Figs. 2230-2231, Operated by Switch and Lock Movement. Pennsylvania Railroad.



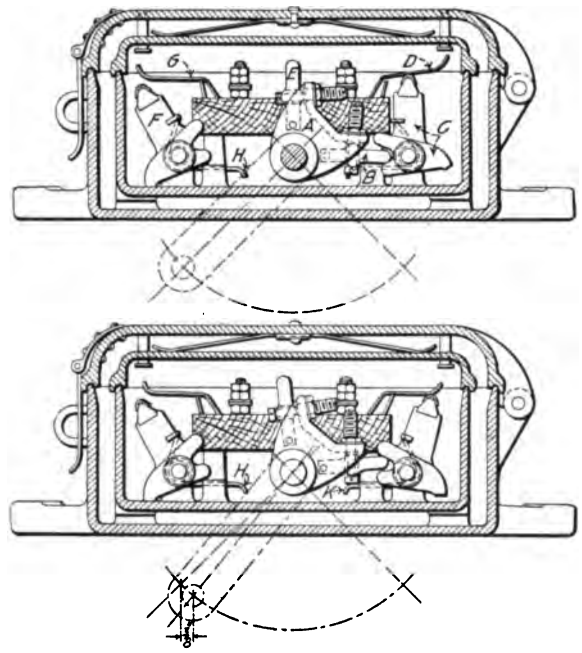




Figs. 2233-2235. Shunt Switchbox, with Front and Back Contacts. General Railway Signal Company.

Fig. 2236. Switchbox and Selector. General Railway Signal Company.

Fig. 2237. Switchbox, Fig. 2236, with Cover Open.



Figs. 2238-2239. Sectional Views of Switchbox, Figs. 2236-2237.

Names of Parts of Switchbox, Figs. 2238-2239.

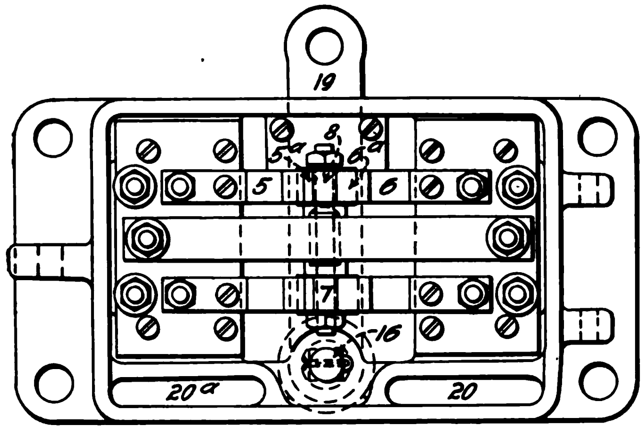
A *Adjusting Arm*
B *Right-Hand Operating Arm*
C *Right-Hand Contact Arm*
D *Right-Hand Contact Spring*
E *Left-Hand Operating Arm*
F *Left-Hand Contact Arm*
G *Left-Hand Contact Spring*
H *Left-Hand Spiral Spring*
K *Right-Hand Spiral Spring*

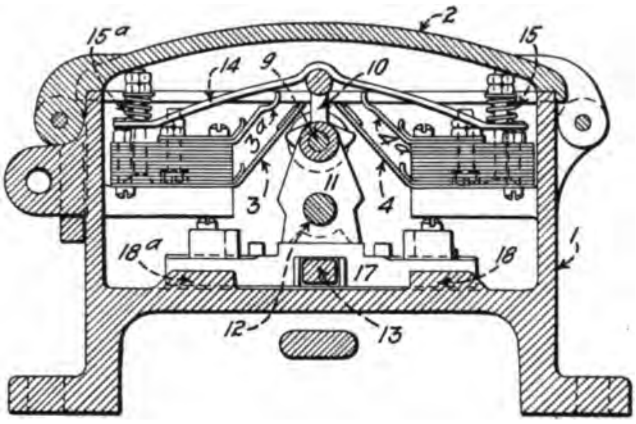
Figs. 2236-2239 show a switchbox made by the General Railway Signal Company and used on the Electric Zone of the New York Central & Hudson River. It is provided with three normal and three reverse contacts, the six springs on each side constituting three pairs, each pair being bridged by a brass contact plate. These plates are carried by hard rubber blocks attached to the top of the contact arm. The lower part of the contact arm is formed into a jaw at one end, and those jaws are engaged by the operating arms, which are adjustable. The adjusting arm A is rigidly attached to the shaft, which is moved by the operating lever.

When the switch is normal, the parts assume the position shown in Fig. 2238. The operating arm B engages the jaw of the contact arm C, forcing it downward and drawing up the contact plates against the springs D, bending them upward. This holds the three normal contacts closed. As the switch starts to move to its reverse position, B is raised and the spiral spring K forces C away from the contact springs. However, if the spiral spring should be broken the operating arm B would accomplish the same result before disengaging with the jaw.

When the operating lever is in the center of its stroke, neither jaw is engaged and all contacts are open. In the last ⅜ in. of its stroke, the operating lever brings the operating arm E into engagement with F, closing the reverse contacts G, in the same manner as were D in the extreme normal position.

It will be seen from the above that this switchbox is designed for use where control circuits are broken and is not desirable where track circuits are to be shunted. The switch shown in Figs. 2233-2235 is designed for shunting purposes.





Figs. 2240-2241. Switchbox. Federal Signal Company.

Names of Parts of the Federal Signal Company's Switchbox; Figs. 2240-2241.

1	*Case*	**13**	*Tongue*
2	*Cover*	**14**	*Yoke*
3-6a	*Contact Springs*	**15-15a**	*Helical Springs*
7-8	*Insulated Rollers*	**16**	*Vertical Spindle*
9	*Toggle Pin*	**17**	*Slide*
10	*Toggle Link*	**18-18a**	*Guide S*
11	*Tumbler*	**19**	*Crank Arm*
12	*Horizontal Spindle*	**20-20a**	*Openings for Wires*

Figs. 2240-2241 show a switchbox made by the Federal Signal Company. Mounted in the case on insulated supports are contacts 3, 3-A, 4, 4-A, 5, 5-A, 6 and 6-A, which are closed by the insulated rollers 7 and 8, carried by toggle pin 9. The toggle is composed of link 10 and tumbler 11, which hangs on pin 9. The tumbler 11 rotates on stationary spindle 12, and is actuated by the slide 17. The upper end of link 10 engages with the concave portion of yoke 14, which is forced down against the upper end of toggle 10 by helical springs 15 and 15-A. The tongue 13 is attached to vertical spindle 16 and engages with and moves slide 17 in guides 18 and 18-A. This slide engages the portion of tumbler 11, which is below spindle 12, and as slide 17 moves either to right or left, it causes tumbler 11 to swing on spindle 12 until the hinge pin 9 reaches a point on either side of center. After reaching this point, the springs 15 and 15-A force the yoke 14 down, causing the toggle to close contacts on the side to which it swings. The vertical spindle 16 extends through the bottom of case 1 and attached to it is crank arm 19. This arm is operated to left or right by the switch point.

The circuit to be opened is broken during the first 3° of movement of the crank 19, and the circuit to be closed is made up during the last 3° of movement of the crank. During the intermediate movement of the crank, the contacts remain in the position shown. Other arrangements of contacts can be made; contacts may be made up during the first 3° of movement of crank and others remain closed until the last 3° of movement of crank 19.

Fig. 2243. Circuit Controller, Fig. 2242, with Cover Removed, Showing Contact Springs Mounted on Slate Blocks.

Fig. 2242. Circuit Controller for Signals, Levers, etc. Railroad Supply Company.

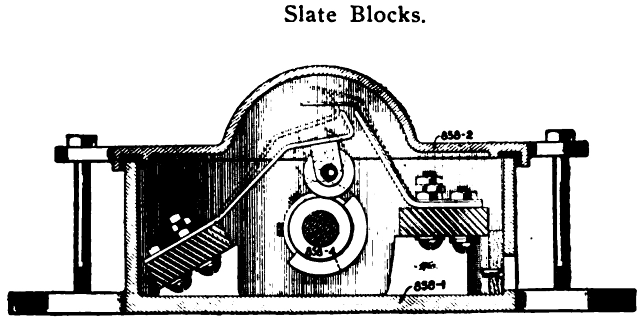
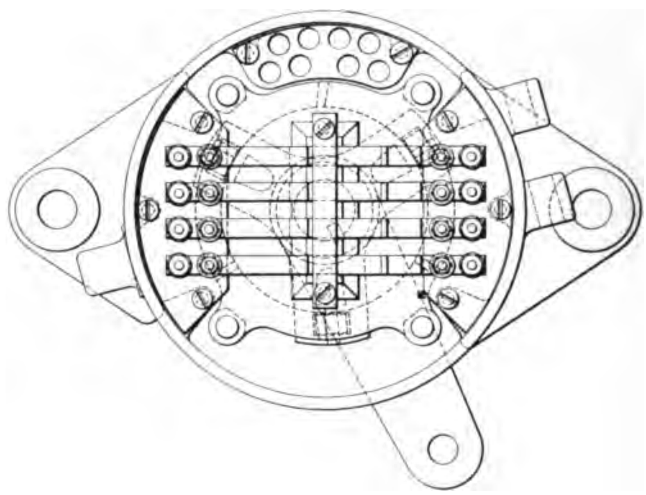
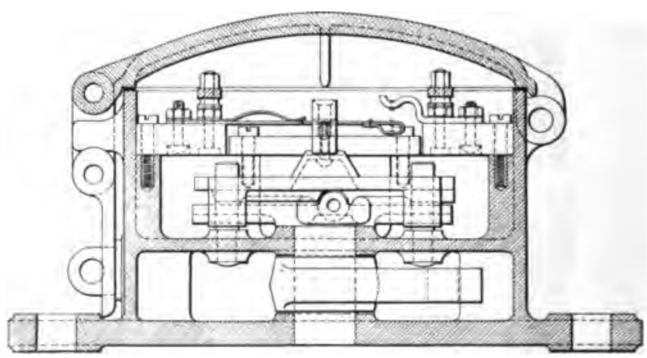


Fig. 2244. Sectional View of Figs. 2241-2242, Showing Operation of Parts.

Fig. 2245. Switchbox. American Railway Signal Company.

Fig. 2246. Switchbox, Fig. 2245, with Cover Open.





Figs. 2247-2248. Plan and Section of Switchbox, Figs. 2245-2246.

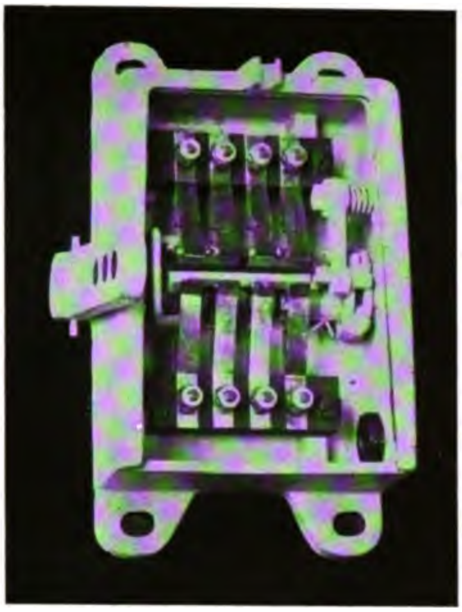


Fig. 2249. Circuit Controller for Signals, Levers, etc. General Railway Signal Company.

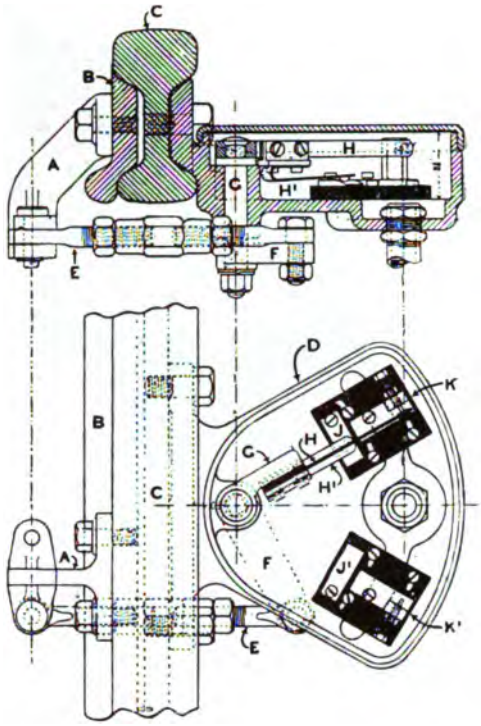


Fig. 2250. Electrical Point Detector (Switchbox). W. R. Sykes' Interlocking Company, Limited, of London.

Names of Parts, Electrical Point Detector; Fig. 2250.

- **A** *Lug*
- **B** *Switch Point*
- **C** *Stock Rail*
- **D** *Case*
- **E** *Operating Rod*
- **F** *Crank Arm*
- **G** *Contact Arm and Shaft*
- **H H[1]** *Contact Springs*
- **J J[1]** *Contact Plates*
- **K K[1]** *Adjustable Contact Points*

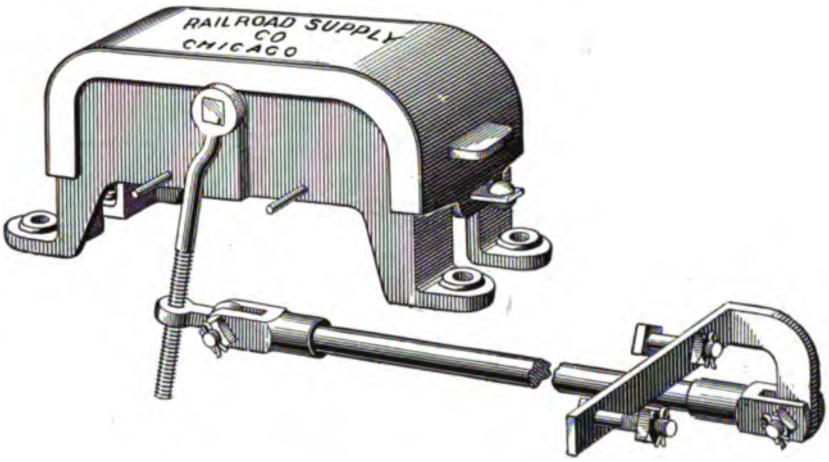


Fig. 2251. Switchbox. Railroad Supply Company.

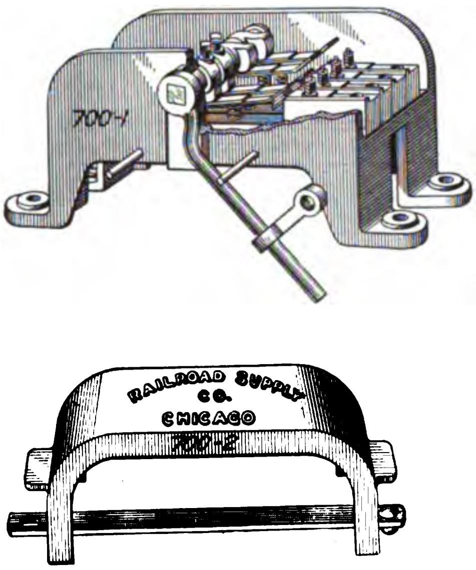
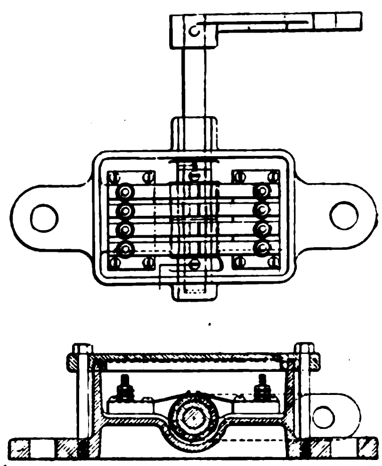


Fig. 2252. Details of Switchbox, Fig. 2251.



Figs. 2253-2254. Circuit Controller, Roller Type, for Signals, Levers, etc. General Railway Signal Company.

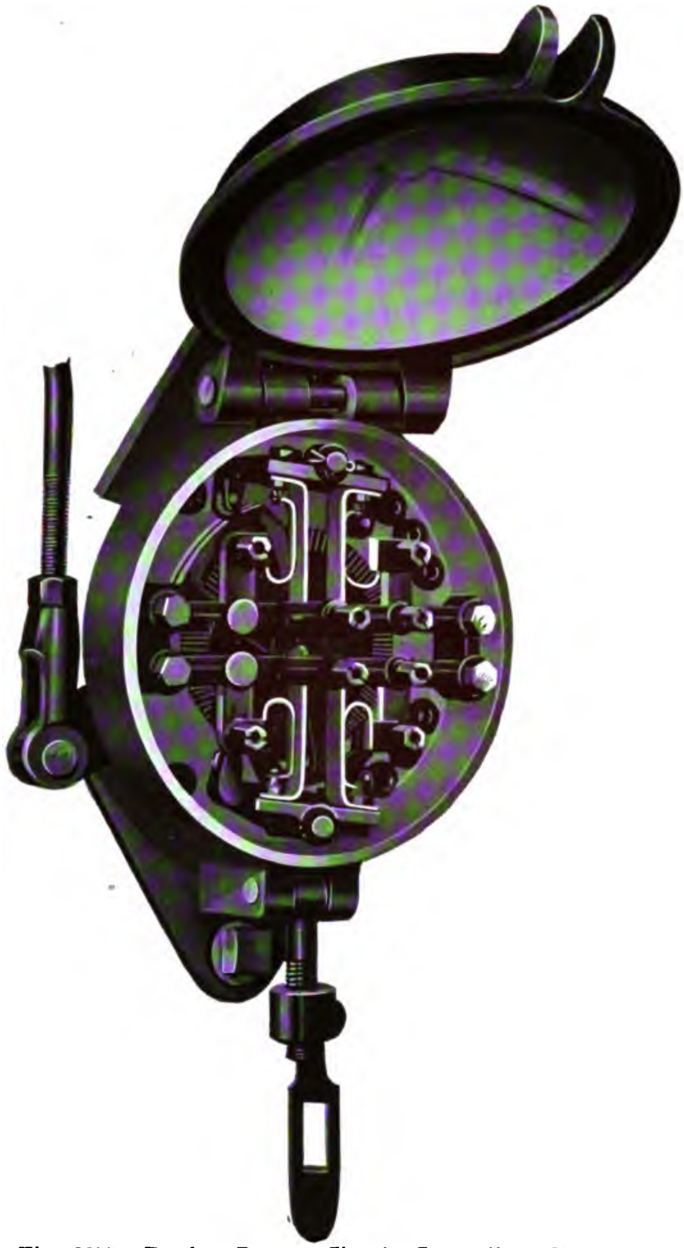
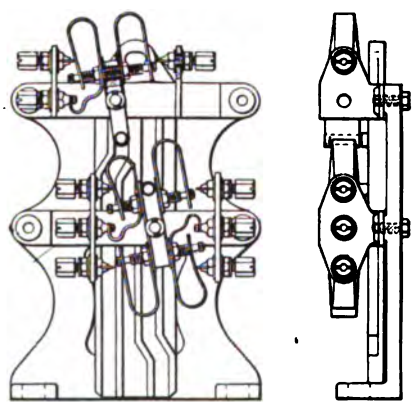


Fig. 2255. Duplex Rotary Circuit Controller. The Union Switch & Signal Company.



Figs. 2256-2257. Combined Motion Plate Pole Changer and Circuit Controller for Electro-Pneumatic Dwarf Slide Signal, Fig. 1953.

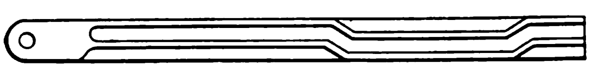
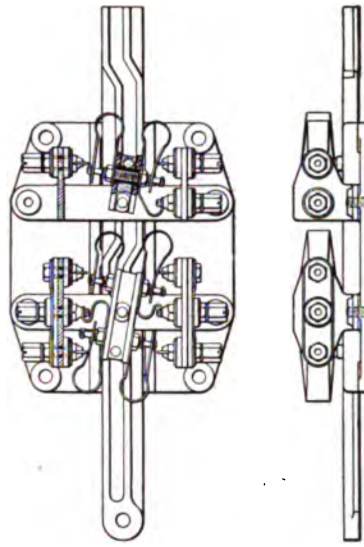
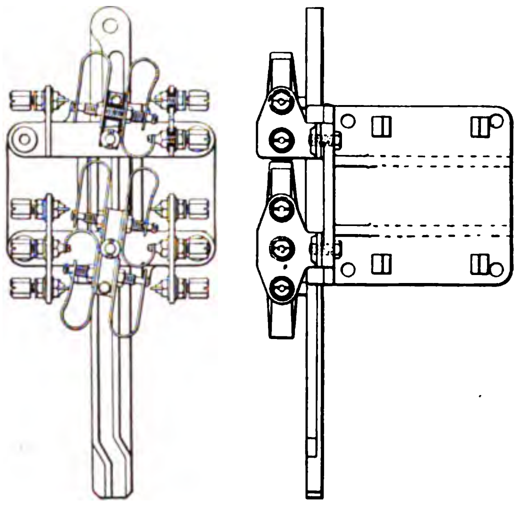


Fig. 2262. For Circuit Controller, Closing Two Circuits at Clear and One at Stop.



Figs. 2258-2259. Combined Motion Plate Pole Changer and Circuit Controller for Electro-Pneumatic Signal. See Figs. 454-455.



Figs. 2260-2261. Combined Motion Plate Pole Changer and Circuit Controller for Electro-Pneumatic Slide Signal, Figs. 537-538 and 540-541.

Fig. 2263. For Circuit Controller, Closing One Circuit at Clear and Two at Stop.

Fig. 2264. For Combined Pole Changer and Circuit Controller, Opening Circuit When Starting to Clear and Operating Pole Changer at Clear.

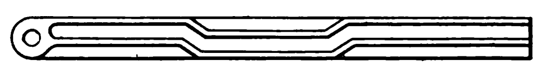


Fig. 2265. For Combined Pole Changer and Circuit Controller for Three Position Signal, Opening Circuit When Starting to Clear.

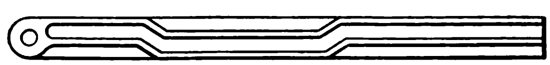
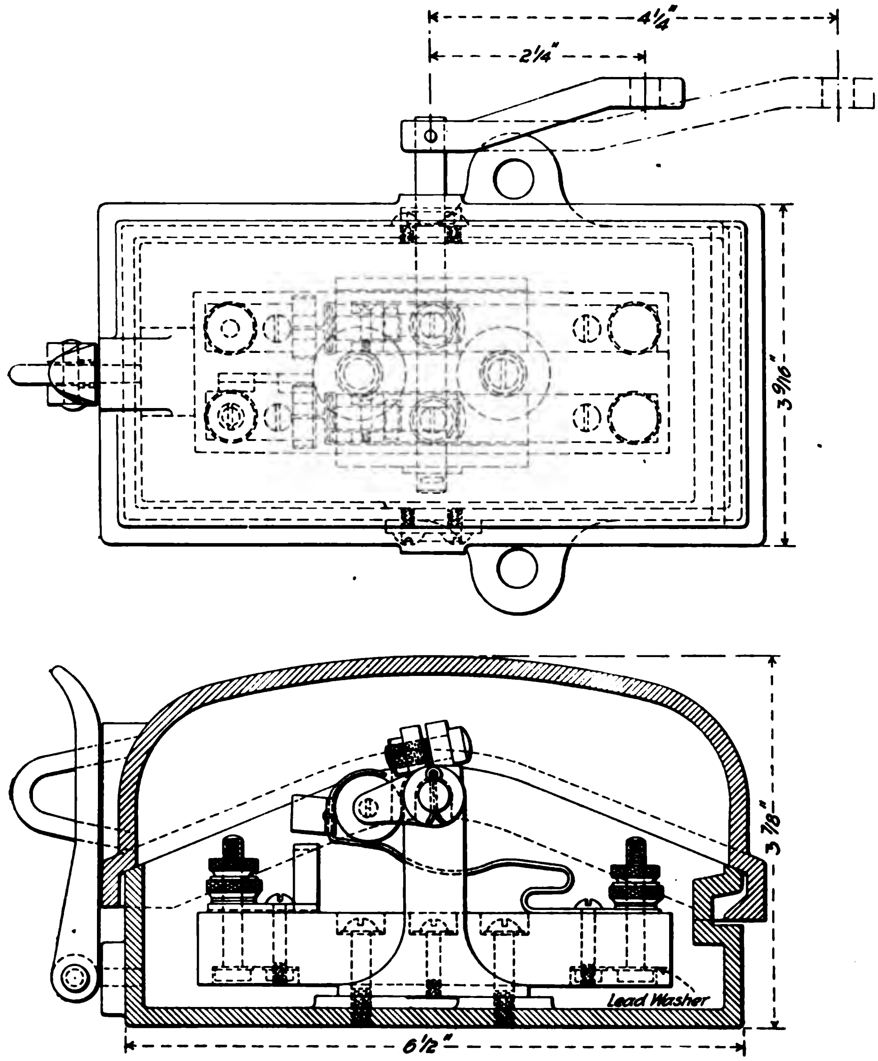
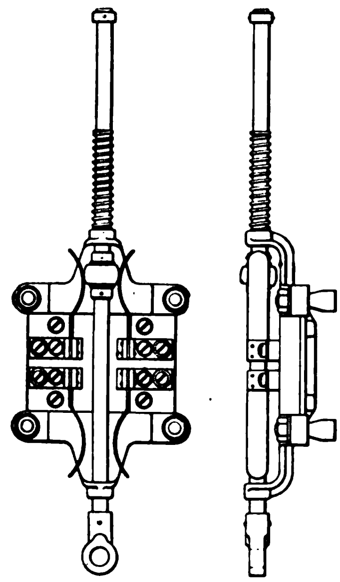


Fig. 2266. For Combined Pole Changer and Circuit Controller, Operating Both When Starting to Clear.

Figs. 2262-2266. Circuit Controller Motion Plates for Various Combinations Used with Electro-Pneumatic Signals. The Union Switch & Signal Company.





Figs. 2269-2270. Circuit Controller for Electro-Pneumatic Signals. The Union Switch & Signal Company.

Figs. 2267-2268. Circuit Controller for Signals, etc. Hall Signal Company.

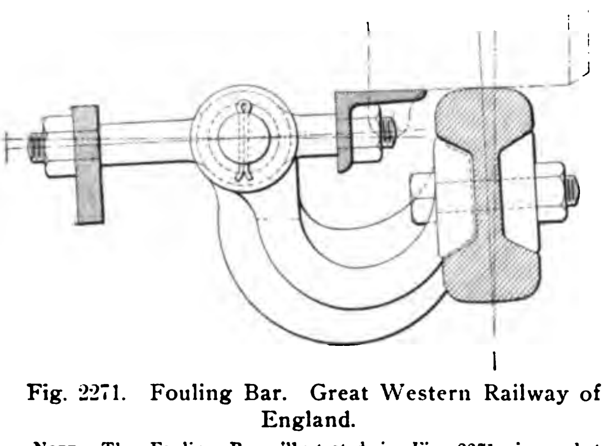
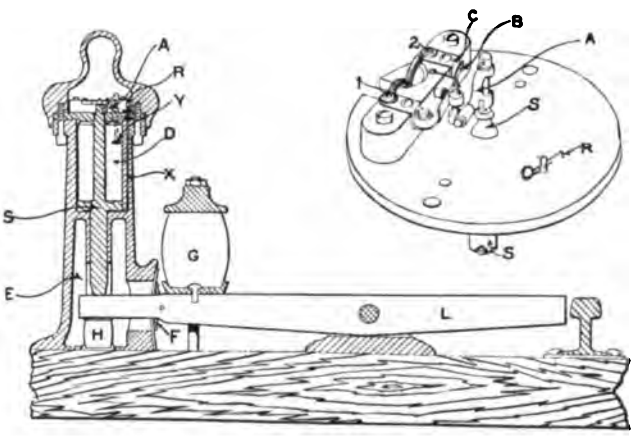


Fig. 2271. Fouling Bar. Great Western Railway of England.

NOTE.—The Fouling Bar, illustrated in Fig. 2271, is used to operate a circuit controller, thereby locking a switch or signal until the train is off the bar and clear of a certain section of track.



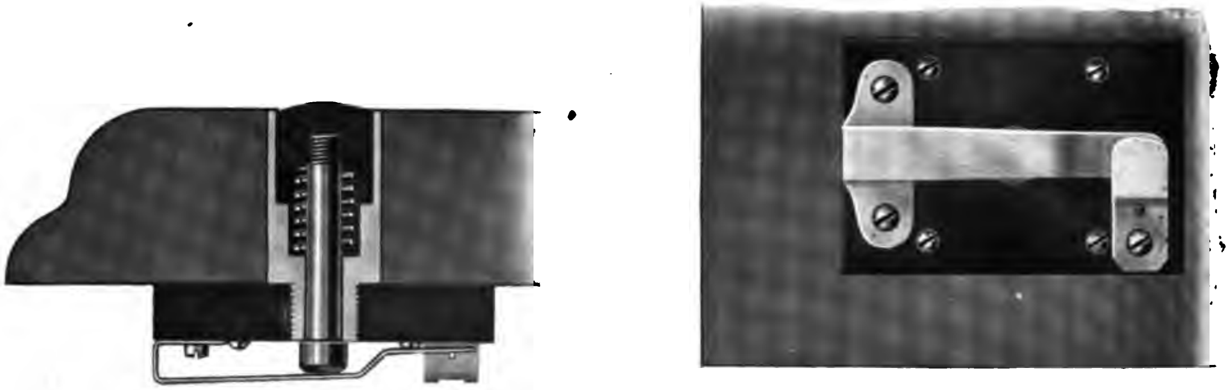
Figs. 2272-2273. Track Instrument. See Figs. 609-611. Hall Signal Company.

Names of Parts, Hall Track Instrument; Figs. 2272-2273.

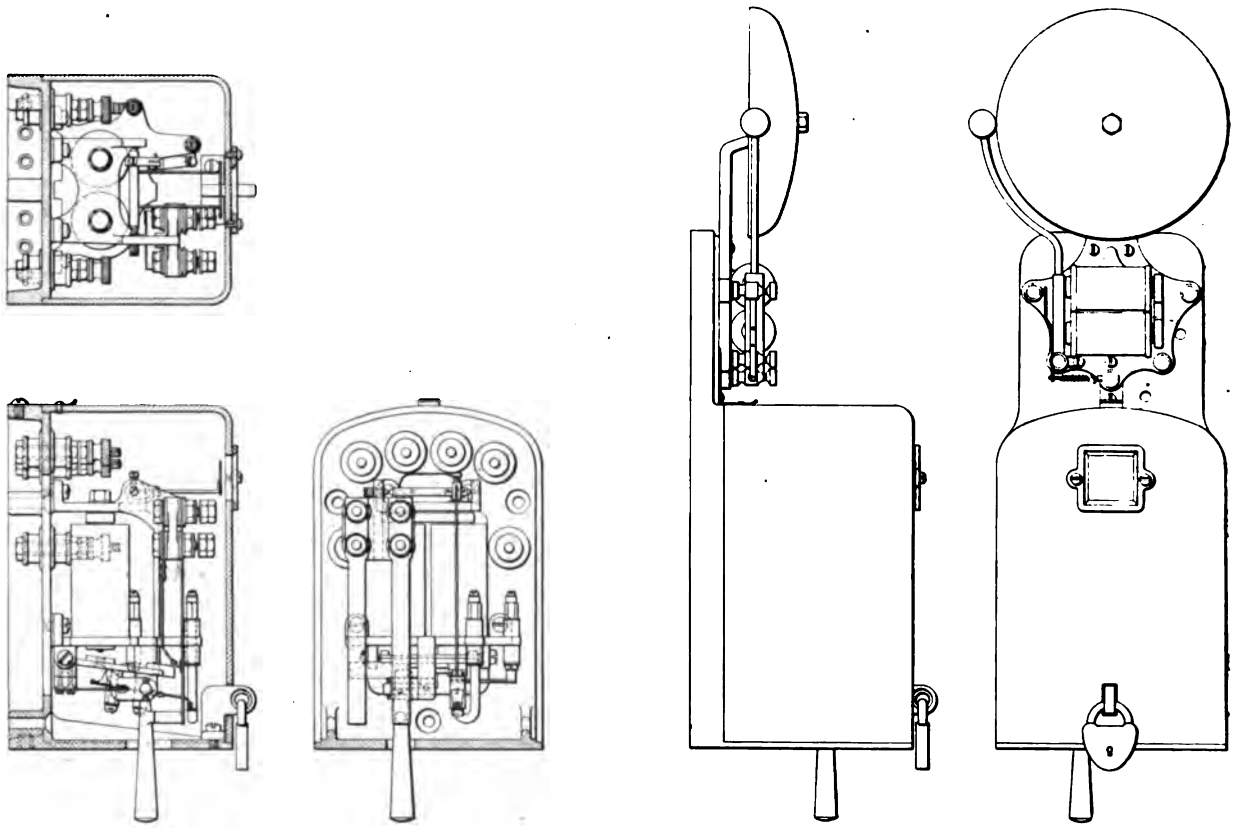
1, 2	*Terminal Screws*	**G**	*Large Rubber Spring*
A	*Swinging Arm*	**H**	*Small Rubber Spring*
B	*Contact Spring*	**L**	*Lever*
C	*Anvil*	**R**	*Valve*
D	*Air Chamber*	**S**	*Piston and Rod*
E	*Chamber in Base*	**X**	*Air Passage*
F	*Dust Guard and Spring*	**Y**	*Port*

Figs. 2272-2273 show the track instrument made by the Hall Signal Company. Depression of lever L by the wheels of a train forces piston S upward. This piston moves in an air chamber D, and communicates motion to the swinging arm A of the circuit controlling apparatus.

Upper and lower ends of the air chamber D are connected with each other by an air passage X, and valve R, so arranged that when piston S is forced upward, a portion of the air above the piston is forced out through the port Y through valve R and passage X, to the under side of the piston. Continued raising of the piston covers opening Y, and shuts off communication between top and bottom of chamber D. The air remaining forms a cushion preventing the piston rod from being thrown forcibly up against the cover. The beveled top of the piston rod extends through the plate on which the contacts are mounted and when raised engages the roller of swinging arm A, forcing spring B into contact with its anvil C, thereby completing a circuit. Air below the piston also acts as a cushion to prevent shocks when the piston falls. R is a valve for regulating the air pressure. Its lower extremity covers the top of the passage X. G and H are rubber springs so compressed that any weight less than that imposed by the pressure of an ordinary car wheel fails to operate the piston. Contact springs can be arranged either normally open as shown, or normally closed, and they can be furnished in multiple for the control of several circuits.



Figs. 2274-2275. Table Circuit Controller. The Union Switch & Signal Company.



Figs. 2276-2280. Magnetic Circuit Controller, With and Without Bell. The Union Switch & Signal Company.

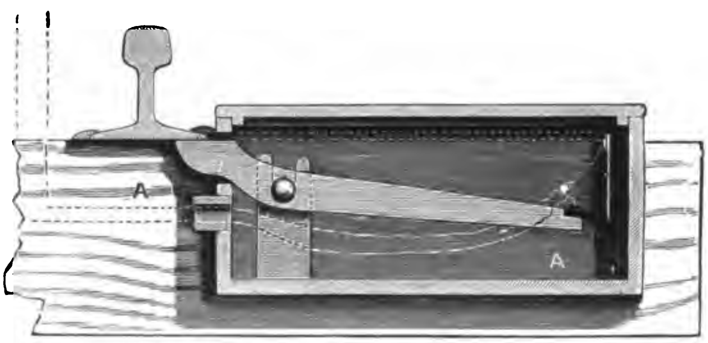


Fig. 2281. The O'Neil Track Instrument. Railroad Supply Company.

Fig. 2282. Double Pole Single Throw Knife Switch, Porcelain Base. Central Electric Company.

Fig. 2284. Double Circuit Controller for Use with Mechanical Interlocking Machines. The Union Switch & Signal Company.

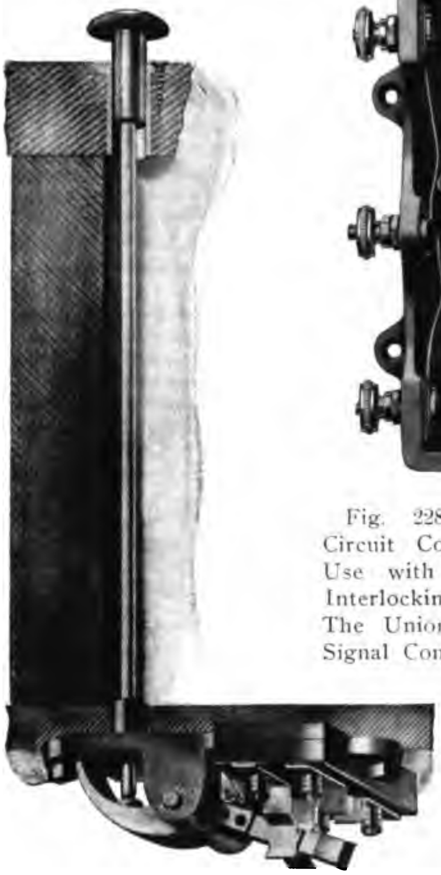
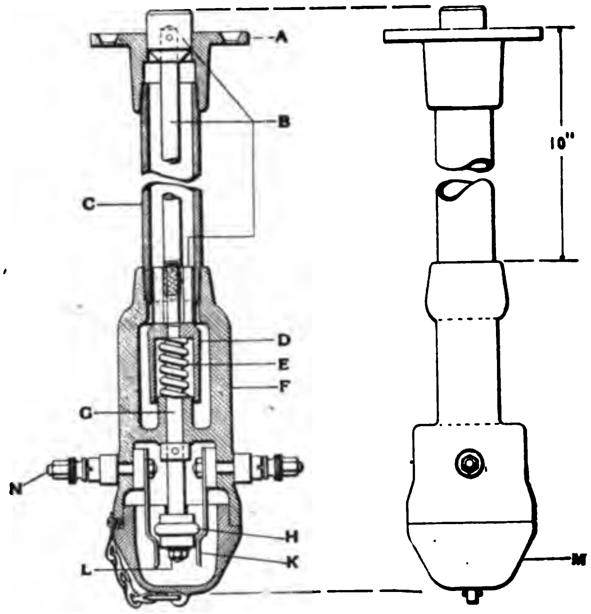


Fig. 2283. Floor Push. Railroad Supply Company.

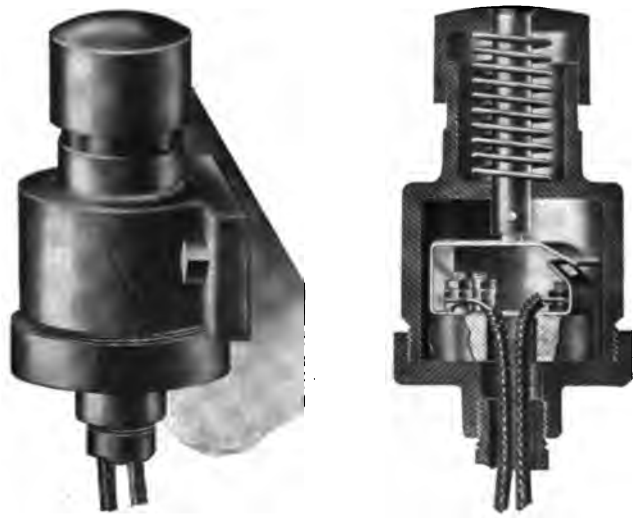
Names of Parts of Floor Push; Figs. 2285-2286.

- **A** *Floor Socket*
- **B** *Plunger*
- **C** *1" Wrought Iron Pipe*
- **D** *Shield*
- **E** *Spring*
- **F** *Contact Box*
- **G** *Steel Rod*
- **H** *Contact Ring*
- **K** *Contact Spring*
- **L** *Brass Nut*
- **M** *Cap*
- **N** *Binding Post*

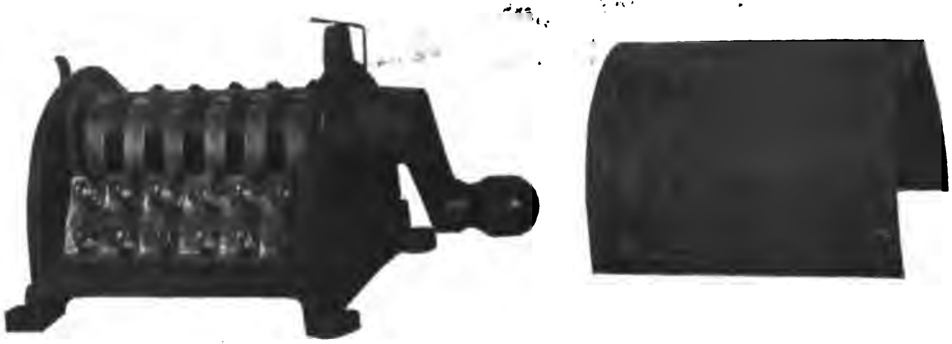


Figs. 2285-2286. Floor Push. General Railway Signal Company.

In the floor push shown in Figs. 2285-2286, the circuit is closed by pushing down on the plunger B; this compresses spring E, and brings contact ring H against springs K. Ring H is mounted on an insulating bushing held in place on rod G by the nut L. Shield D is fastened to rod G, and diverts all water and dirt that may enter from above to the cavity in F, thus keeping the contacts clean and free from corroding influences.



Figs. 2287-2288. Weather-Proof Floor Push. Railroad Supply Company.



Figs. 2289-2290. Hand Circuit Controller and Cover. The Union Switch & Signal Company.

Fig. 2291. Table Push. The Union Switch & Signal Company.

Fig. 2292. Single Circuit Controller for Use with Mechanical Interlocking Machine. The Union Switch & Signal Company.

Fig. 2293. Double Pole Single Throw Knife Switch, Porcelain Base. Railroad Supply Company.

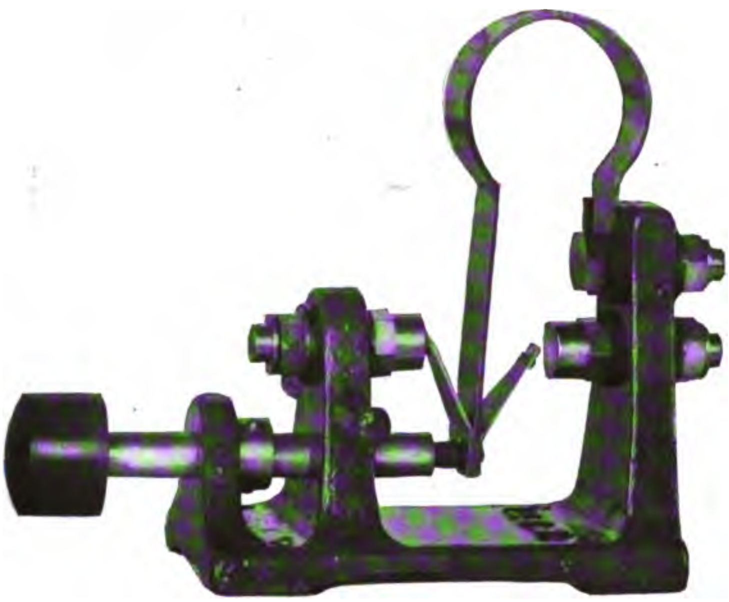


*Fig. 2294. Bell Key.

Fig. 2296. Cam Circuit Controller. The Union Switch & Signal Company.

The circuit controller shown in Fig. 2296 is designed to be placed underneath the top plate of an interlocking machine and operated by a lever striking the small arm projecting to one side.

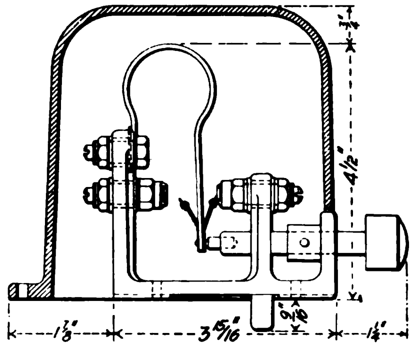


Fig. 2295. Bell Key, Fig. 2294, in Case. The Union Switch & Signal Company.

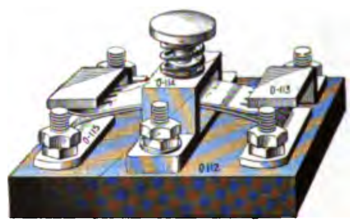


Fig. 2297. Push Key. Railroad Supply Company.

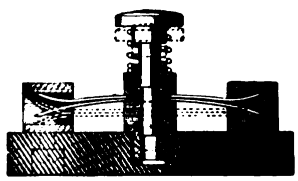
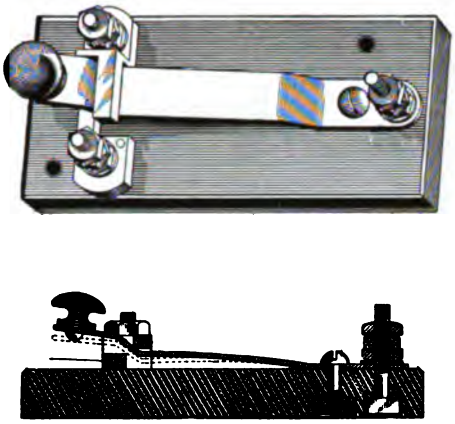


Fig. 2298. Sectional View of Fig. 2297, Showing Operation of Key.



Figs. 2299-2300. Strap Key. Railroad Supply Company.

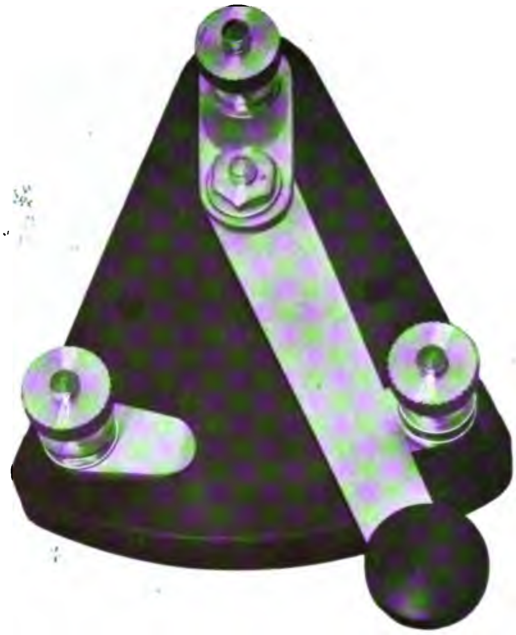


*Fig. 2301. Two-Point Switch.

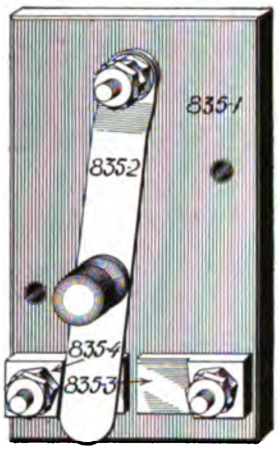
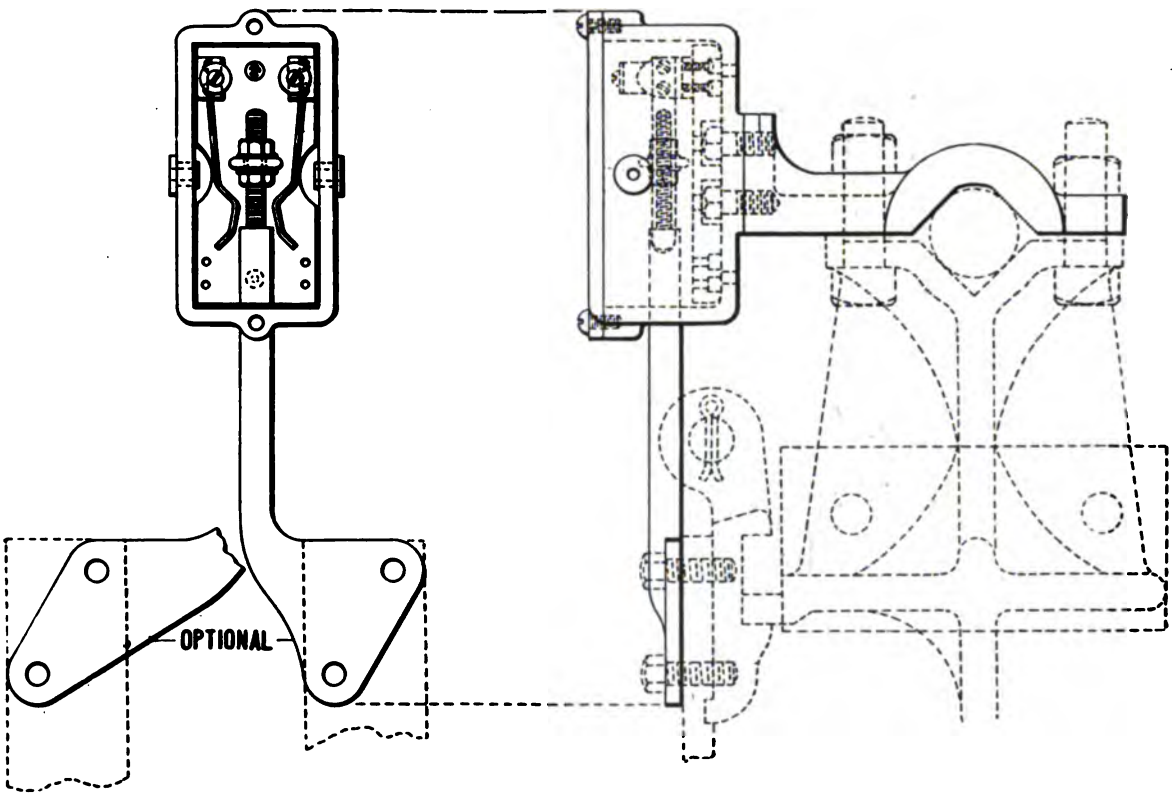


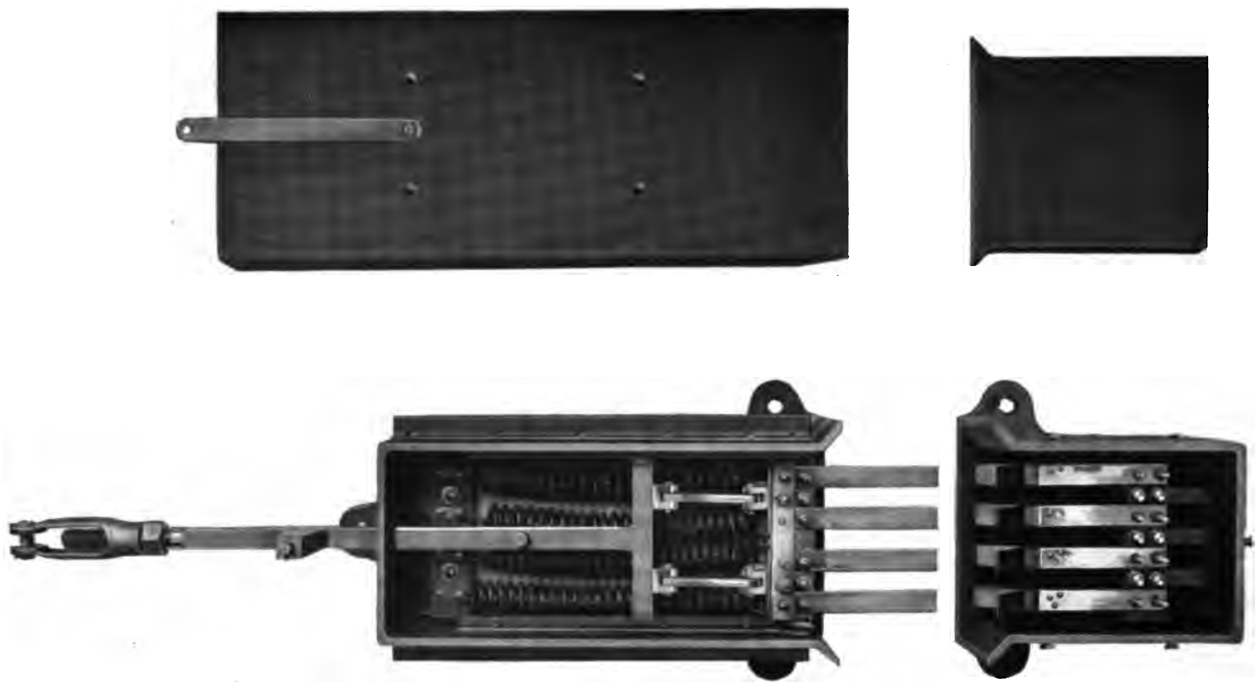
Fig. 2302. Two-Point Switch, Slate Base. Railroad Supply Company.

*Fig. 2303. Two-Point Switch, Hard Rubber Base.

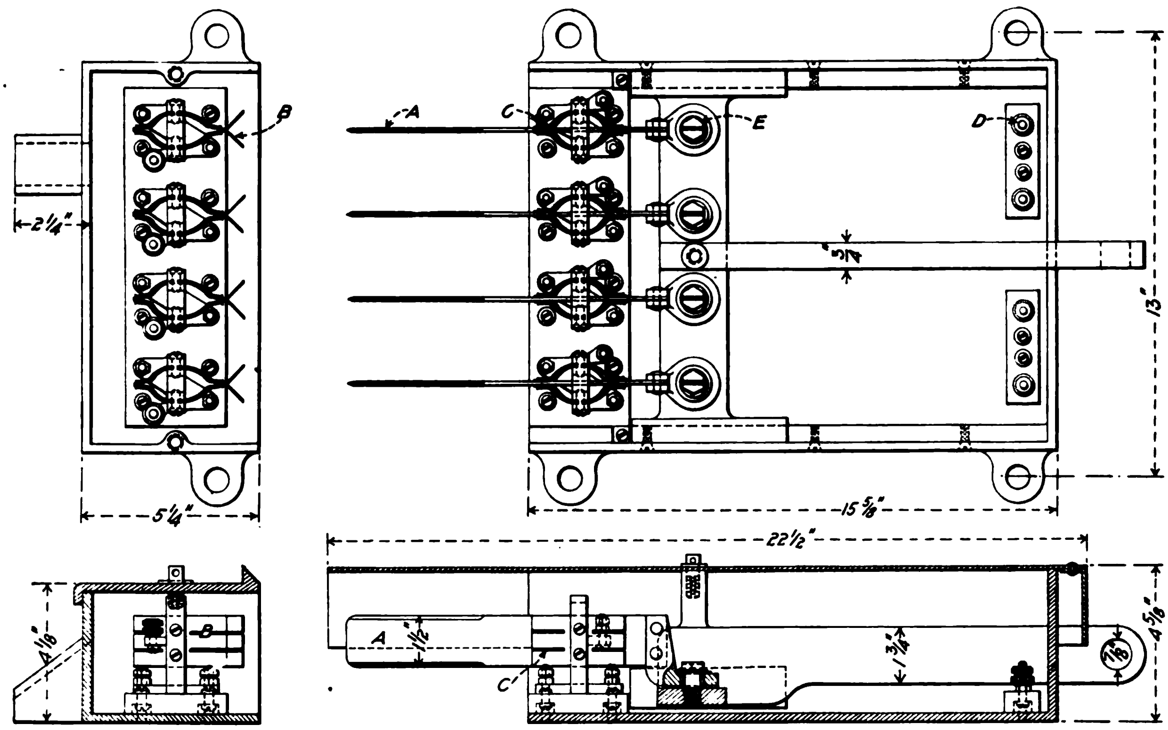
Fig. 2304. Double Pole Single Throw Knife Switch with Cartridge Fuse Protection, Slate Base. Central Electric Company.



Figs. 2305-2306. Tappet Circuit Controller. General Railway Signal Company.



Figs. 2307-2310. Electric Bridge Coupler. The Union Switch & Signal Company.



Figs. 2311-2314. Bridge Circuit Controller. Hall Signal Company.

Names of Parts of Hall Bridge Circuit Controller; Figs. 2311-2314.

A *Contact Blade*
B *Contact Jaw*
C *Contact Jaw Leaf*
D *Fixed Terminal Binding Posts*
E *Movable Terminals*

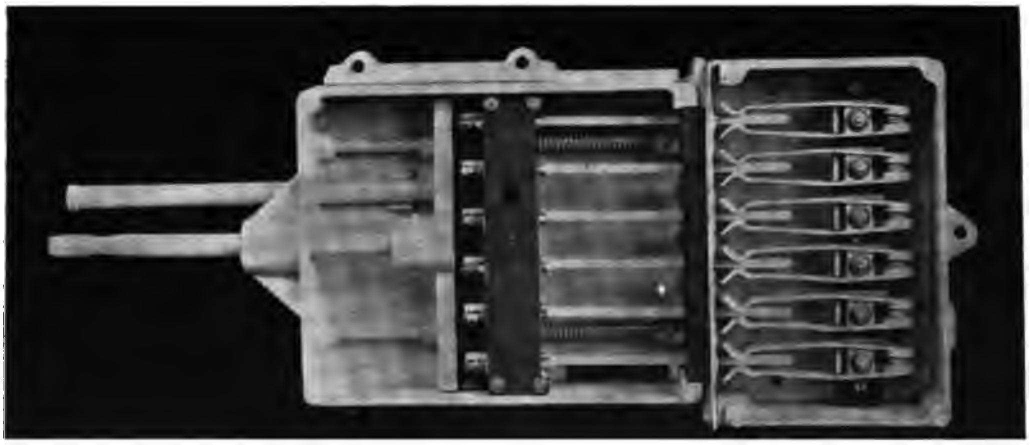


Fig. 2315. Bridge Circuit Closer; Contacts Closed. General Railway Signal Company.

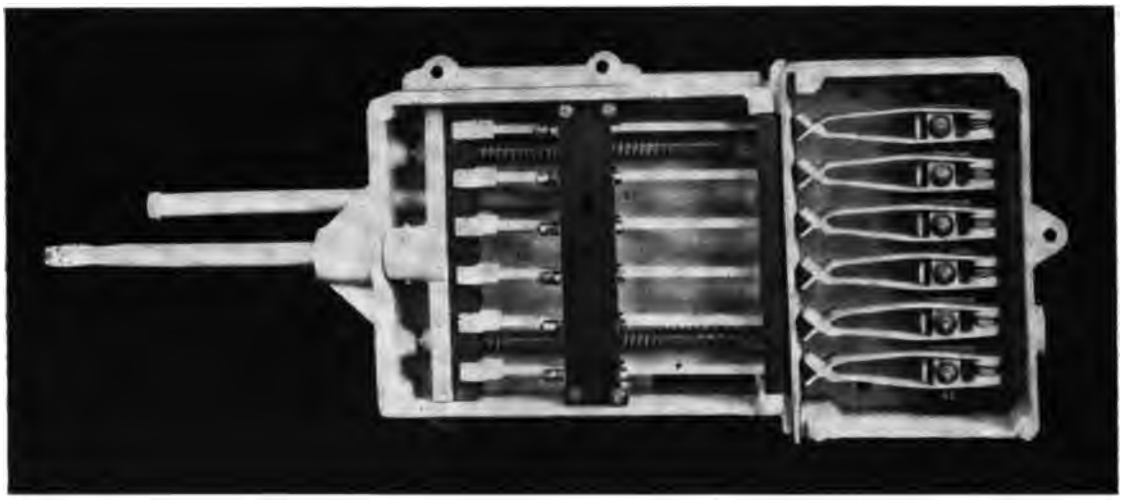


Fig. 2316. Bridge Circuit Closer, Fig. 2315; Contacts Withdrawn.

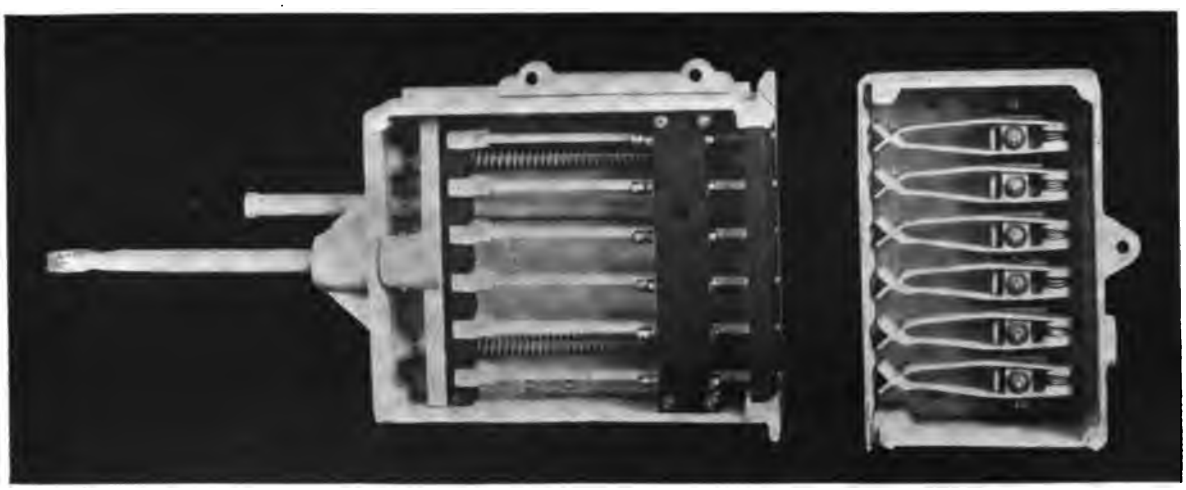


Fig. 2317. Bridge Circuit Closer, Figs. 2315-2316; Slide Withdrawn, Ready for Opening Bridge.

Fig. 2318. Electric Lock. General Railway Signal Company.

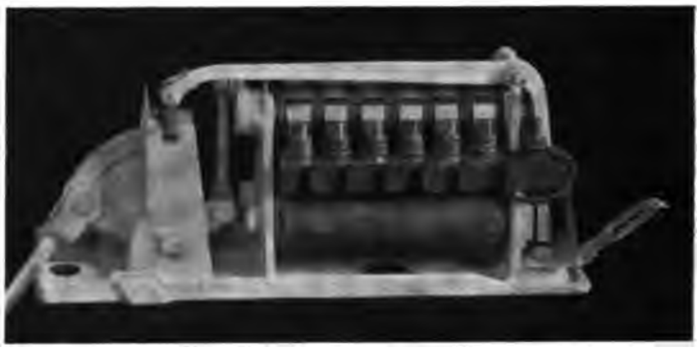


Fig. 2319. Electric Lock, Fig. 2318, Cover Removed; Segment Engaged by Dog.

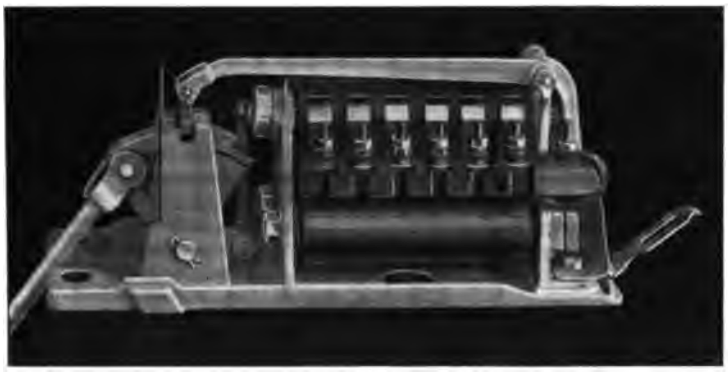
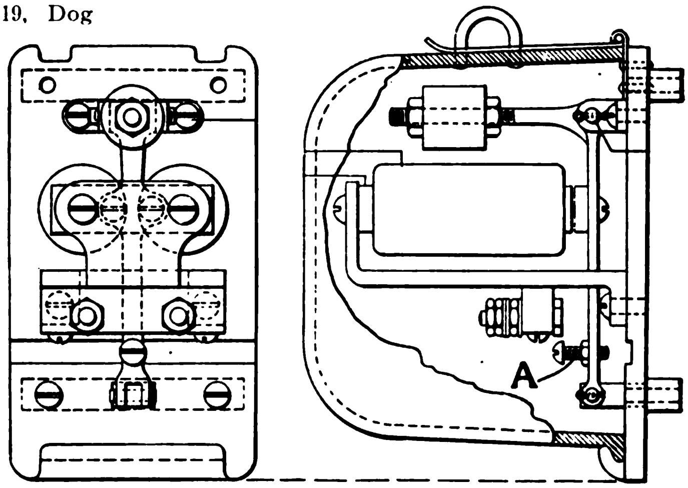


Fig. 2320. Electric Lock, Figs. 2318-2319, Dog Raised, Segment Released.

Fig. 2321. Electric Lock for Electric Interlocking Machine. See B, Fig. 1781. General Railway Signal Company.



Figs. 2322-2323. Electric Lock for Engaging Tappet of Vertical Locking. General Railway Signal Company.

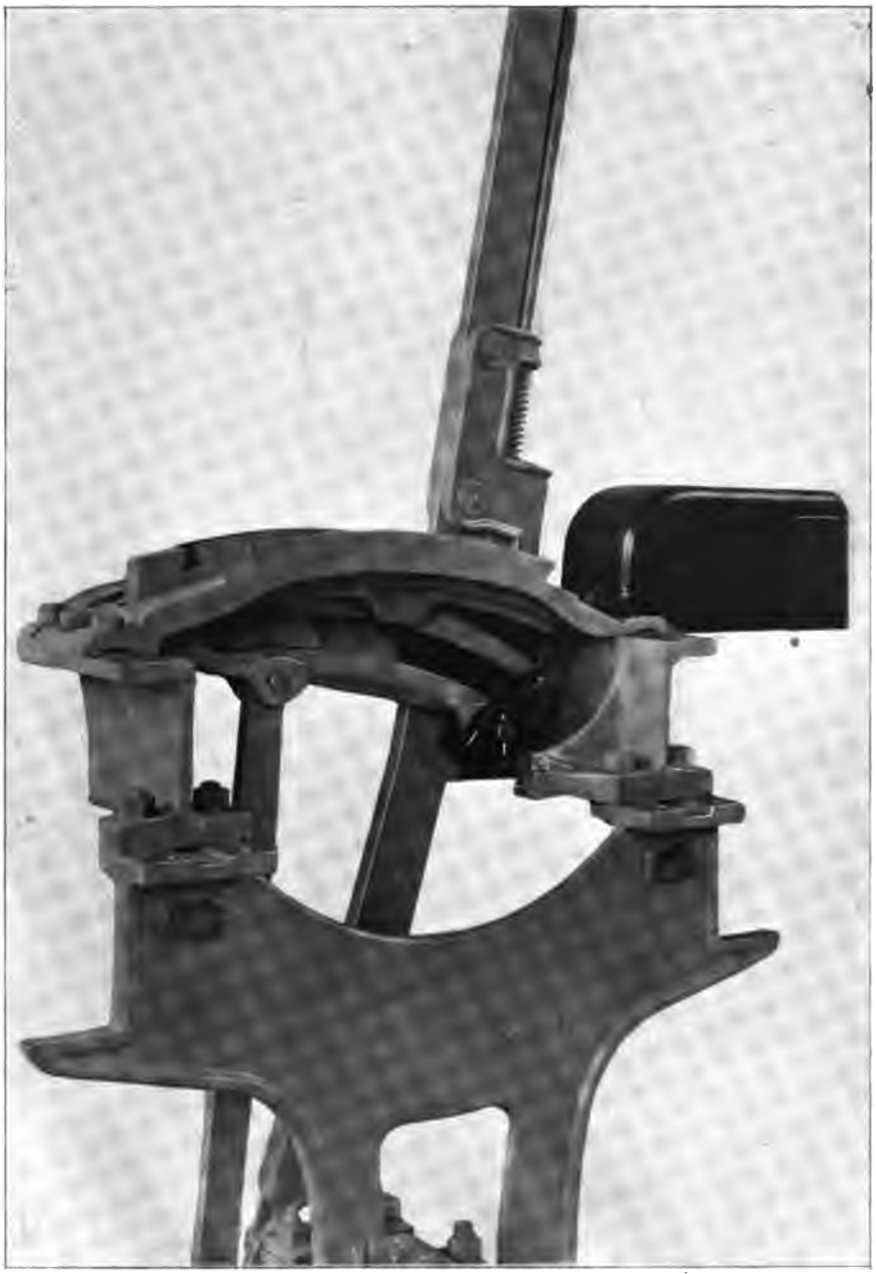


Fig. 2324. Style "B" Electric Lock Applied to Standard Interlocking Machine. General Railway Signal Company.

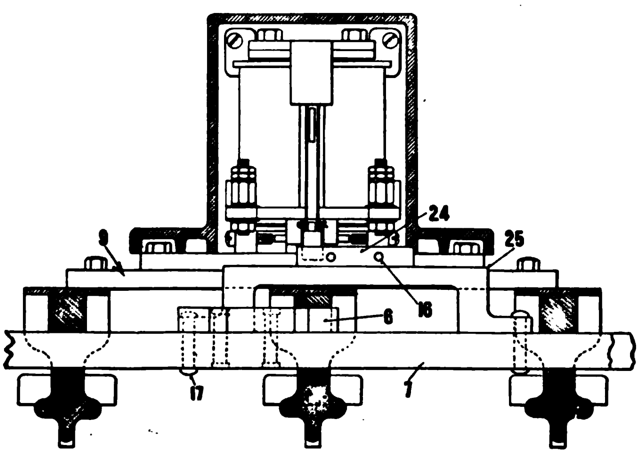


Fig. 2325. Model 2 Electric Lock Applied to Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.

Names of Parts of Model 2, Electric Lock; Fig. 2325.

6 *Dog (Mechanical Locking)*
7 *Locking Bar*
9 *Supporting Plate*
16 *Rivet for* **24**
17 *Rivet for* **25**
24 *Guard Plate*
25 *Locking Dog*

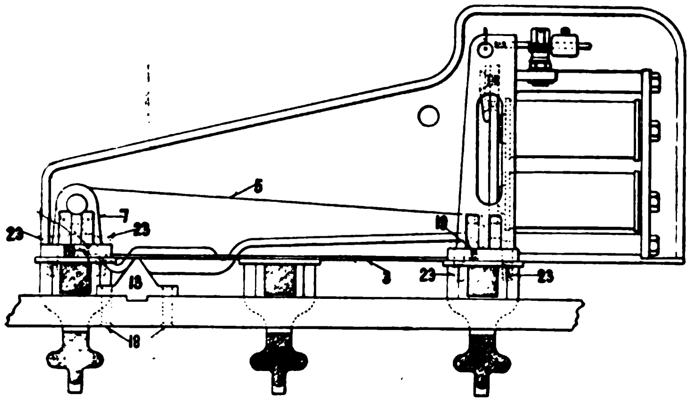


Fig. 2326. Model 1 Electric Lock Applied to Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.

Names of Parts of Model 1 Electric Lock Applied to Saxby & Farmer Interlocking Machine; Fig. 2326.

3 *Slotted Sheet Iron Plate*
5 *Locking Lever*
7 *Fulcrum Bracket*
13 *C. R. S. Dog*
18 *Flat Head Rivet*
19 *Flat Head Screw, Fastening* **3** *to* **7**
23 *Tap Bolts*

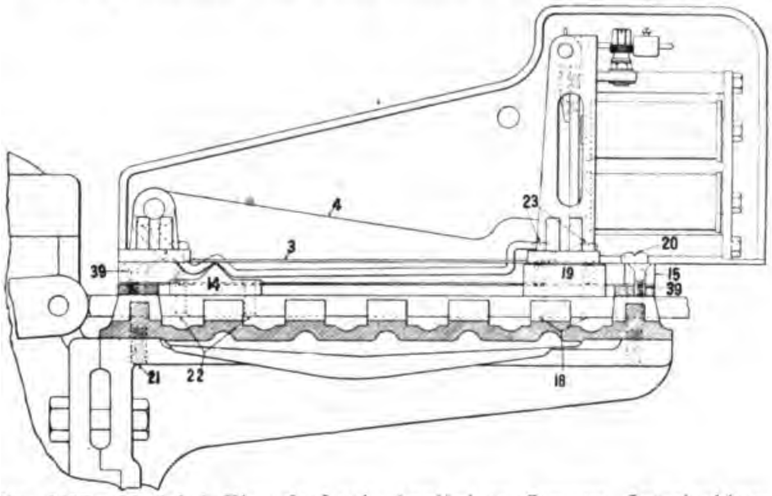


Fig. 2327. Model 1 Electric Lock Applied to Stevens Interlocking Machine. The Union Switch & Signal Company.

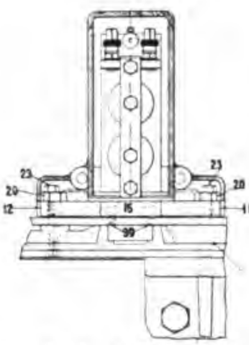


Fig. 2328. End View of Fig. 2327.

Fig. 2329. Style "D" Electric Lock Applied to Dwarf Interlocking Machine. General Railway Signal Company.

Names of Parts of Model 1 Electric Lock Applied to a Stevens Interlocking Machine; Figs. 2327-2328.

3 *Slotted Sheet Iron Plate*
4 *Locking Lever*
11 *Right-Hand Supporting Strip*
12 *Left-Hand Supporting Strip*
14 *C. R. S. Dog*
15 *Filler*
18 *Flat Head Rivet for Fastening* **19** *to Tappet*
19 *C. R. S. Dog*
20 *Tap Bolts for* **11** *and* **12**
21 *Flat Head Tap Bolt for* **11** *and* **12**
22 *Flat Head Rivet for Fastening* **14** *to Tappet*
23 *Tap Bolt for Fastening Frame to* **11** *and* **12**
39 *Flat Head Machine Screw for Fastening* **11** *and* **12** *to Machine.*

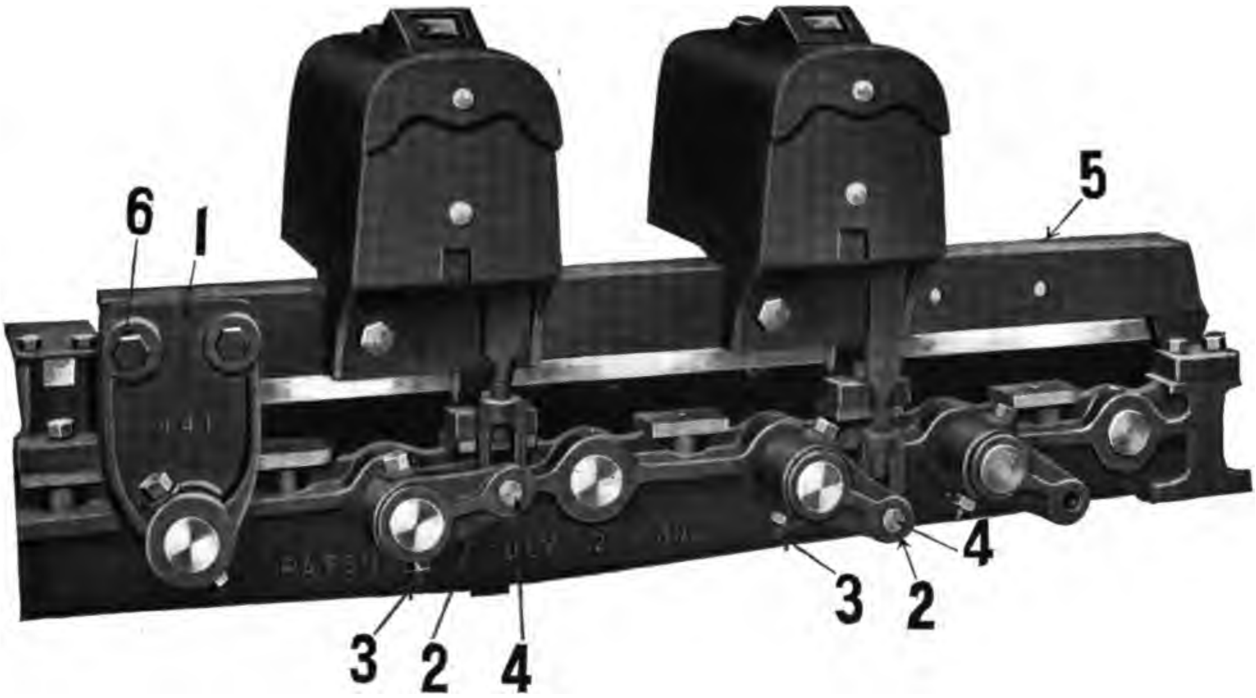


Fig. 2330. Model 3 Electric Lock Applied to Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.

Names of Parts of Model 3 Electric Lock Applied to Saxby & Farmer Interlocking Machine; Fig. 2330.

1 *Intermediate Bracket*	4 *C. R. Steel Turned Pin*
2 *Connecting Arm*	5 *Angle Iron*
3 *Tap Bolt*	6 *Bolt for* 1 *and* 5

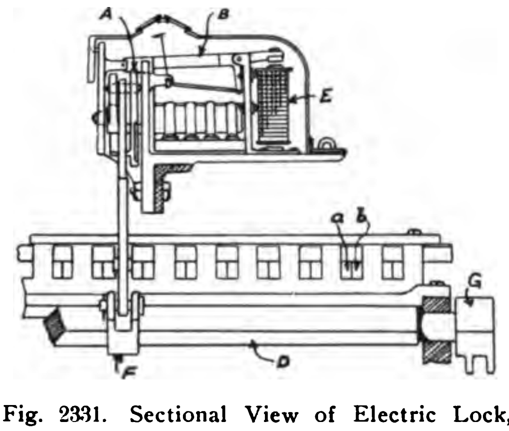


Fig. 2331. Sectional View of Electric Lock, Fig. 2330, Showing Alternative Method of Attaching to Saxby & Farmer Interlocking Machine.

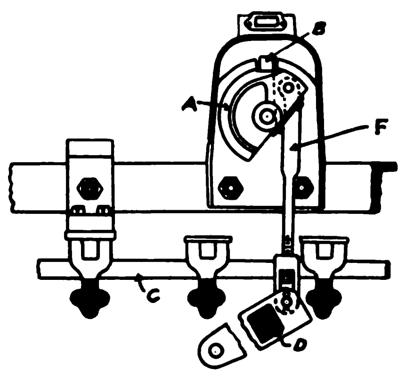


Fig. 2332. Cross Sectional View of Electric Lock, Fig. 2331.

Figs. 2330-2332 illustrate the Model 3 electric lock, made by The Union Switch & Signal Company, applied to a Saxby & Farmer interlocking machine. D is the rotating locking shaft operated by the lever latch. Arm and link F are connected to segment A mounted on a shaft in the lock. The edge of this segment is notched, according to the locking desired, to engage the dog on B, connected by a bar fastened to the armature of the electromagnet E, and so pivoted that the energizing of the magnet E will raise dog on B out of the notch. An indicator is provided to show when unlocked; a circuit controller operated by the magnet and circuit controllers operated by shaft are included in the mechanism for making or breaking circuits controlled by the lever or lock. The bar F may also be attached to the tappet of an interlocking machine with vertical locking. See Figs. 2333-2334.

Names of Parts of Model 3, Electric Lock Applied to National Machine; Fig. 2333.

1 *Connecting Rod*
2 *Lever*
3 *Adjustable Link*
4 *Bracket*
5 *Turned Pin and Cotter*
6 *Turned Pin and Cotter*
7 *Pivot Pin and Cotter*
8 *Machine Bolt*
9 *Tap Bolt*

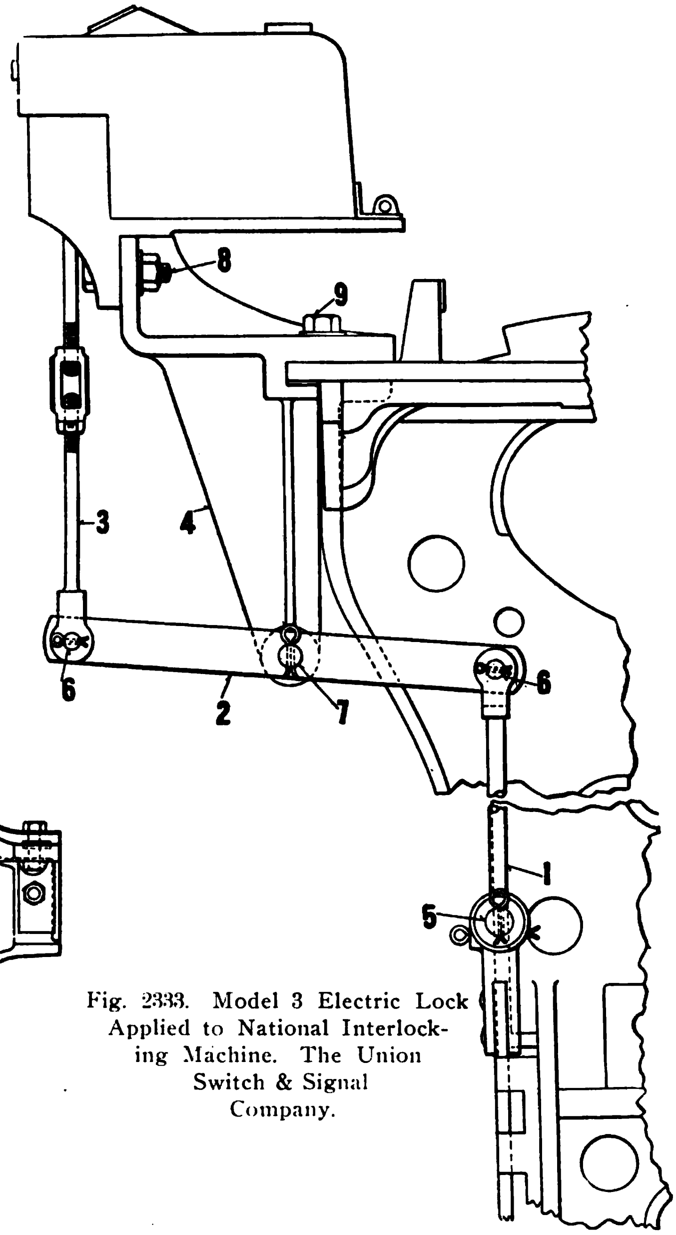


Fig. 2333. Model 3 Electric Lock Applied to National Interlocking Machine. The Union Switch & Signal Company.

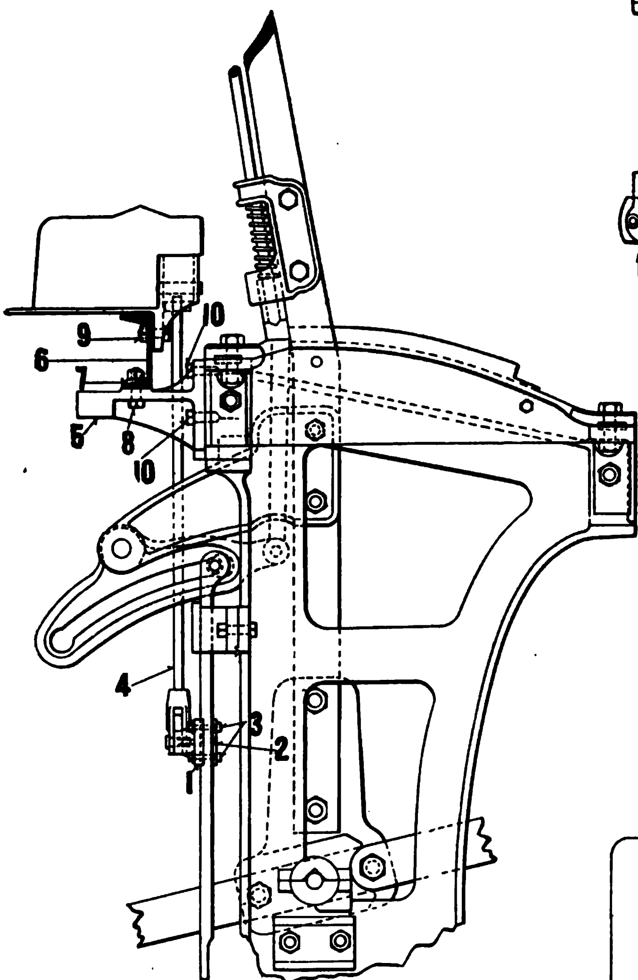


Fig. 2334. Model 3 Electric Lock Applied to Johnson Interlocking Machine. The Union Switch & Signal Company.

Names of Parts of Model 3, Electric Lock Applied to Johnson Machine; Fig. 2334.

1 *Tappet Bar Bracket*
2 *Clamp*
3 *Machine Bolts*
4 *Link*
5 *Bracket*
6 4" *Channel Iron*
7 *Taper Washer*
8 *Machine Bolt*
9 *Machine Bolt*
10 *Tap Bolt*

Numbers Refer to List of Names of Parts on Following Page.

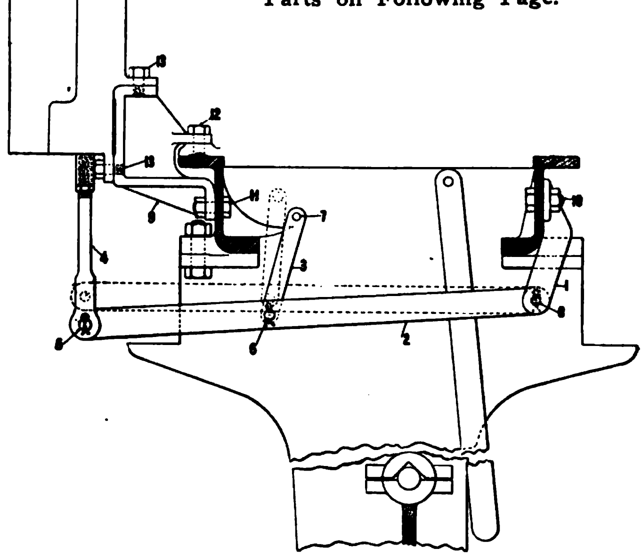


Fig. 2335. Model 7 Electric Lock Applied to a Standard Interlocking Machine. The Union Switch & Signal Company.

Fig. 2336. Model "F" Electric Lock Applied to Saxby & Farmer Interlocking Machine. General Railway Signal Company.

Names of Parts of Model 7 Electric Lock Applied to No. 2 Johnson Machine; Fig. 2337.

1	*Tappet*
2	*Bar*
3	*Dog*
4	*Filler*
5	*Plate*
6	*Flat Head Machine Screw*
7	*Rivet, Countersunk Head*
8	*Supporting Bracket*
9	*Plunger*
10	*Crank*
11	*Pivot Pin and Cotter*
12	*Turned Pin and Cotter*
13	*Washer*
14	*Tap Bolt*
15, 15a	*Machine Bolts*

Names of Parts of Model 7 Electric Lock Applied to Standard Machine; Fig. 2335.

1	*Link Bracket*	7	*Pin and Cotter*
2	*Lock Link*	8	*Stud and Cotter*
3	*Connecting Link*	9	*Lock Bracket*
4	*Solid Jaw*	10	*Machine Bolt*
5	*Pin and Cotter*	11	*Machine Bolt*
6	*Stud and Cotter*	12	*Tap Bolt*
		13	*Tap Bolt*

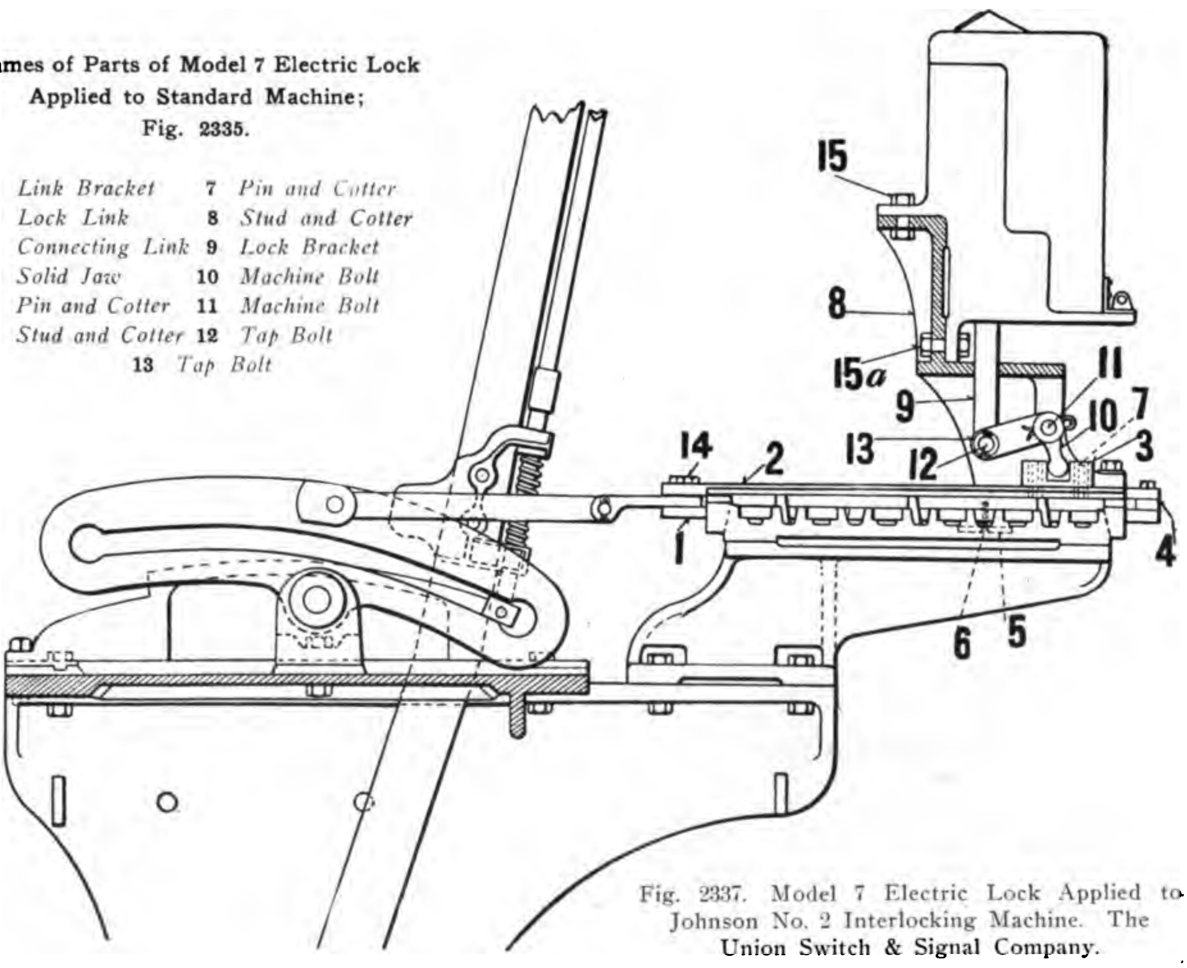
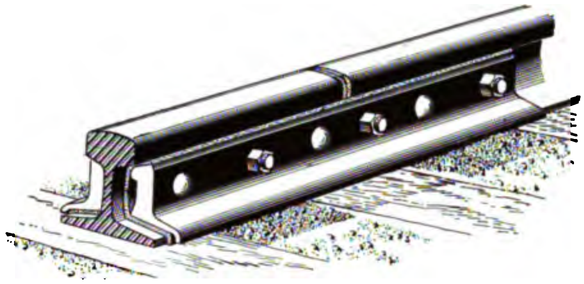
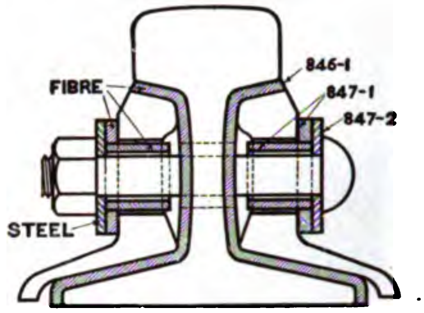


Fig. 2337. Model 7 Electric Lock Applied to Johnson No. 2 Interlocking Machine. The Union Switch & Signal Company.





Figs. 2338-2339. Insulated Rail Joint. Railroad Supply Company.

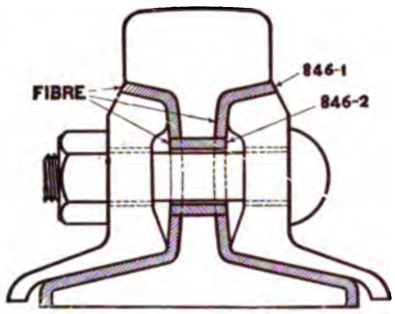


Fig. 2340. Insulated Rail Joint. Railroad Supply Company.

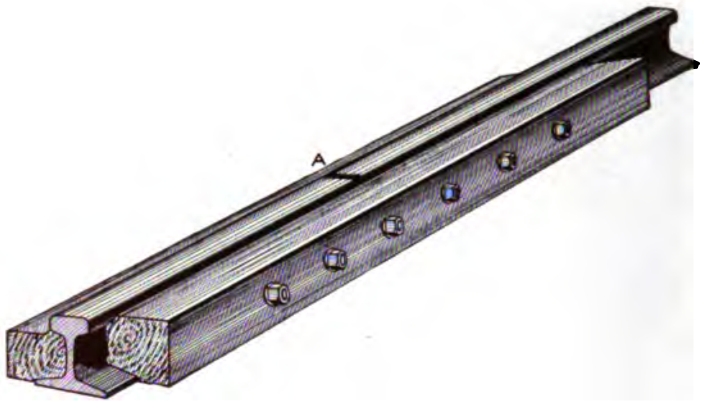
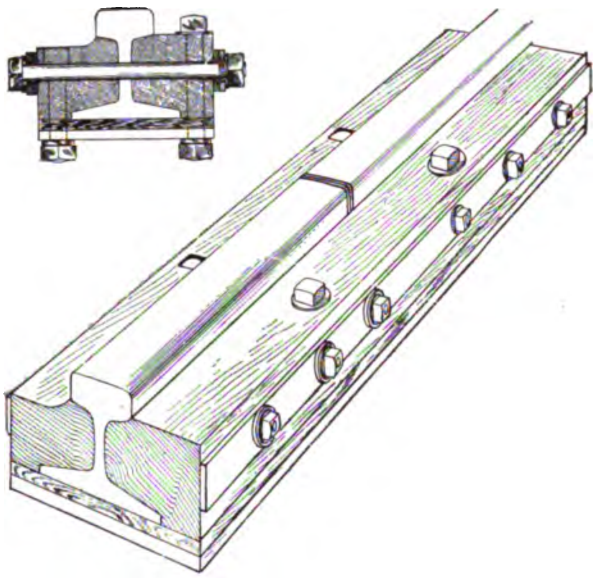
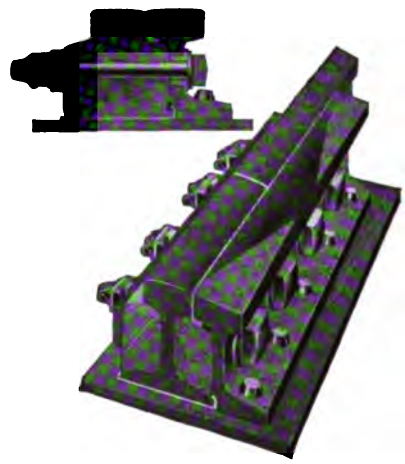


Fig. 2341. Wooden Rail Joint. Railroad Supply Company.

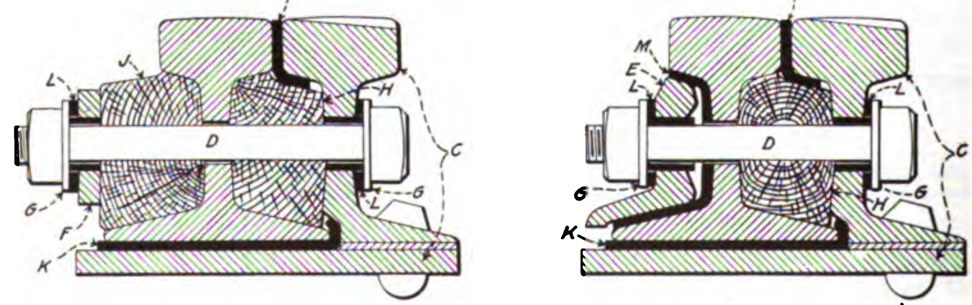


Figs. 2343-2344. Insulated Rail Joint. Railroad Supply Company.



Figs. 2345-2346. Mock Insulated Rail Joint. Buffalo Railway Supply Company.

Letters Refer to List of Names of Parts Below.



Figs. 2347-2348. Details of Mock Insulated Rail Joints.

Names of Parts of Mock Insulated Rail Joints; Figs. 2345-2348.

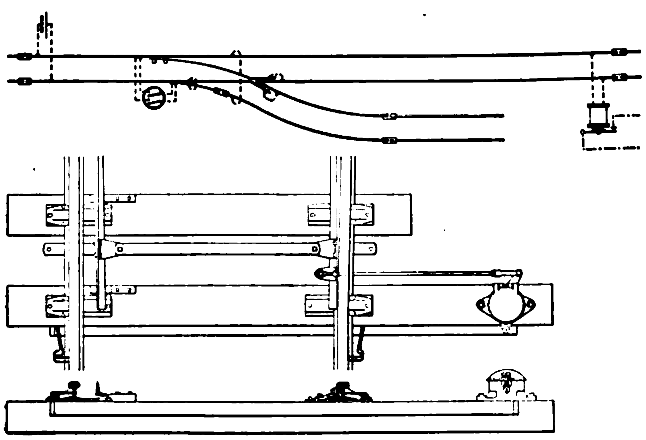
C *Auxiliary Rail Riveted to Steel Plate and Filler*	**F** *Iron Strap*	**J** *Outside Wood*
D *Bolt*	**G** *Iron Washer*	**K** *Fiber Mat (Sole Plate)*
E *Steel Angle Bar*	**H** *Inside Wood*	**L** *Insulating Bushing*
	I *Fiber Strip*	**M** *Fiber Angle*

Fig. 2349. The "Continuous" Joint.

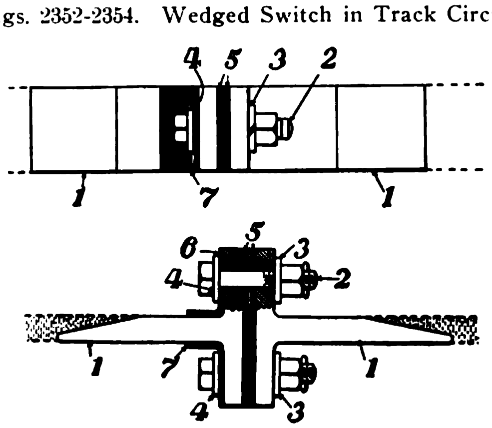
Fig. 2350. The Weber Joint; Wooden Splices.

Fig. 2351. The Weber Joint; Steel Splices.

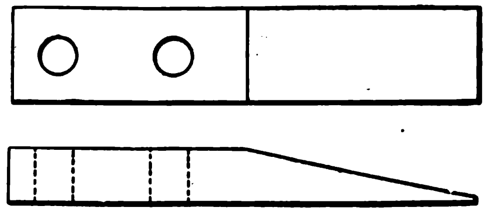
Figs. 2349-2351. Types of Insulated Rail Joints. The Rail Joint Company.



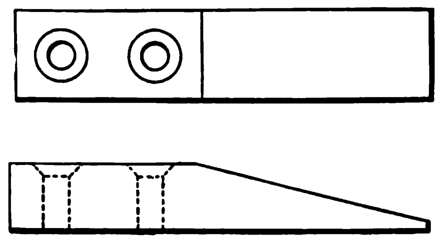
Figs. 2352-2354. Wedged Switch in Track Circuit.



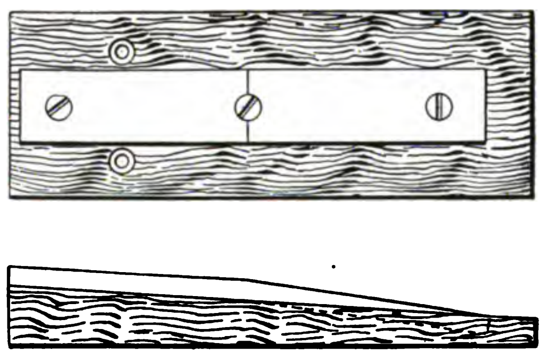
Figs. 2355-2356. Insulated Joint for Welding into Tie Plates, etc. The Union Switch & Signal Company.



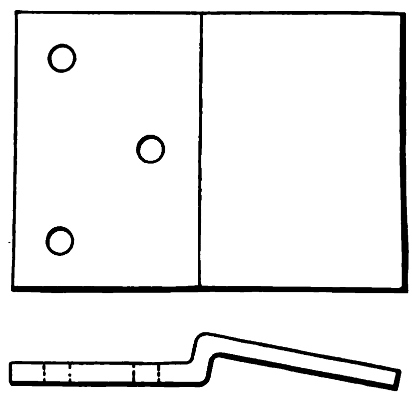
*Figs. 2357-2358. Switch Wedge Drilled for Lag Screws.



*Figs. 2359-2360. Switch Wedge Countersunk for Wood Screws.



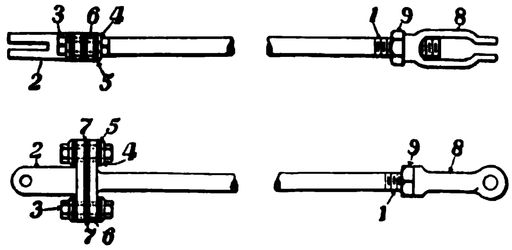
*Figs. 2361-2362. Switch Wedge with Wooden Base.



*Figs. 2363-2364. Switch Wedge Plate.

Names of Parts, Insulated Tie Plate Joint; Figs. 2355-2356.

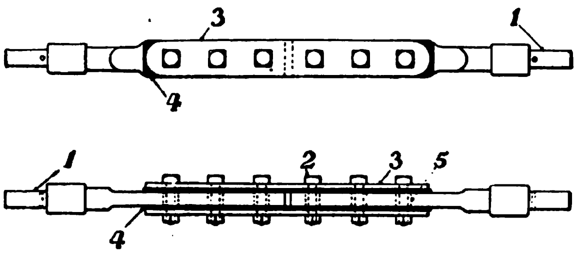
1 *"T" Piece*
2 *Bolt*
3 *Spring Washer*
4 *Pressed Washer*
5 *Fiber Plates*
6 *Fiber Bushing*
7 *Bent Fiber Plate*



Figs. 2365-2366. Insulated Rod with Special Jaw for Rocker Shaft Connection. The Union Switch & Signal Company.

Names of Parts, Insulated Rod with Special Jaw; Figs. 2365-2366.

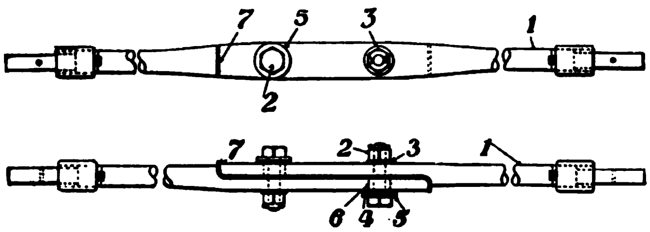
1 *Threaded Rod*
2 *Special "T"-Jaw*
3 *Bolt and Nut*
4 *Steel Washer*
5 *Fiber Washer*
6 *Fiber Bushing*
7 *Fiber Plate*
8 *Screw Jaw*
9 *Jam Nut*



*Figs. 2367-2368. Pipe Line Insulation. (See Details, Figs. 2378-2381.)

Names of Parts, Pipe Line Insulation; Figs. 2367-2368.

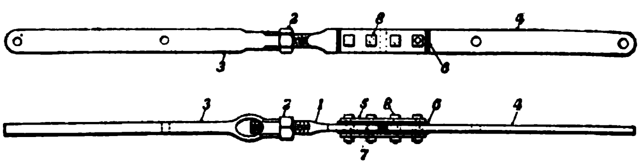
1 *Tang End*
2 *Bolt.*
3 *Splice Plate*
4 *Fiber Plate*
5 *Fiber Bushing*



*Figs. 2369-2370. Pipe Line Insulation.

Names of Parts, Pipe Line Insulation; Figs. 2369-2370.

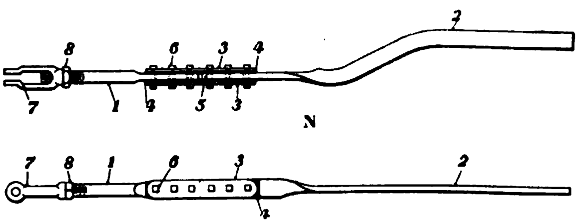
1 *Tang End*
2 *Bolt and Nut*
3 *Spring Washer*
4 *Fiber Washer*
5 *Wrought Washer*
6 *Fiber Bushing*
7 *Fiber Plate*



Figs. 2371-2372. Adjustable Insulated Switch Rod. The Union Switch & Signal Company.

Names of Parts, Adjustable Insulated Switch Rod; Figs. 2371-2372.

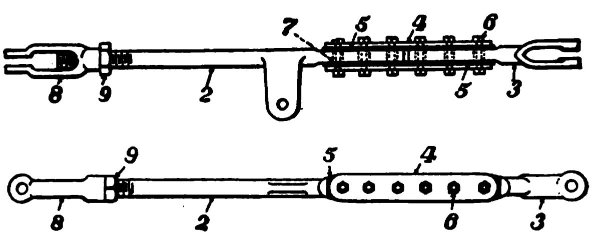
1 *Threaded Piece*
2 *Jam Nut*
3 *Socket Rod*
4 *Plain Rod*
5 *Splice Plate*
6 *Bent Fiber Plate*
7 *Fiber Bushing*
8 *Bolt*



*Figs. 2373-2374. Insulated Lock Rod.

Names of Parts, Insulated Lock Rod; Figs. 2373-2374.

1 *Threaded Rod*
2 *Tappet*
3 *Splice Plate*
4 *Fiber Plate*
5 *Fiber Bushing*
6 *Bolt*
7 *Screw Jaw*
8 *Jam Nut*



*Figs. 2375-2376. Adjustable Insulated Front Rod.

Names of Parts, Adjustable Insulated Front Rod; Figs. 2375-2376.

2 *Lug Rod*
3 *Solid Jaw*
4 *Splice Plate*
5 *Fiber Plate*
6 *Fiber Washer*
7 *Fiber Bushing*
8 *Screw Jaw*
9 *Jam Nut*

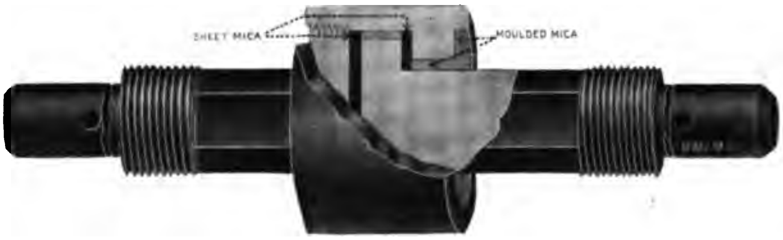
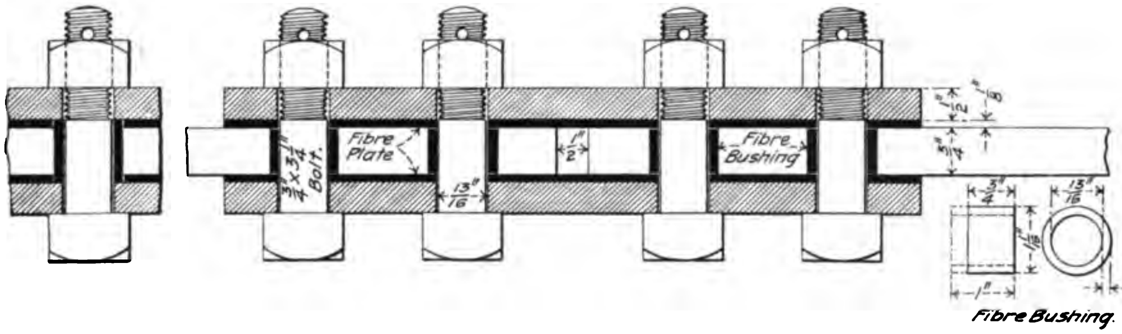


Fig. 2377. Pipe Line Insulation. H. W. Johns-Manville Company.



*Figs. 2378-2381. Insulated Switch Rod Details.

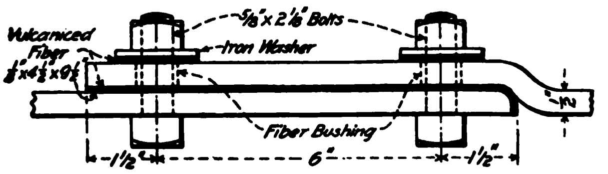
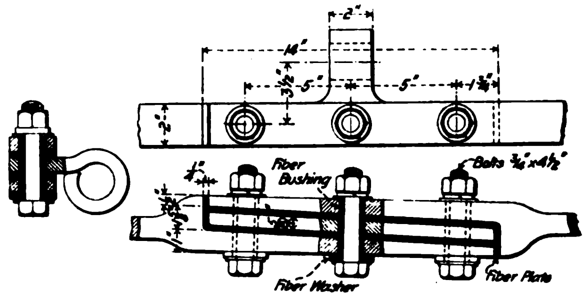
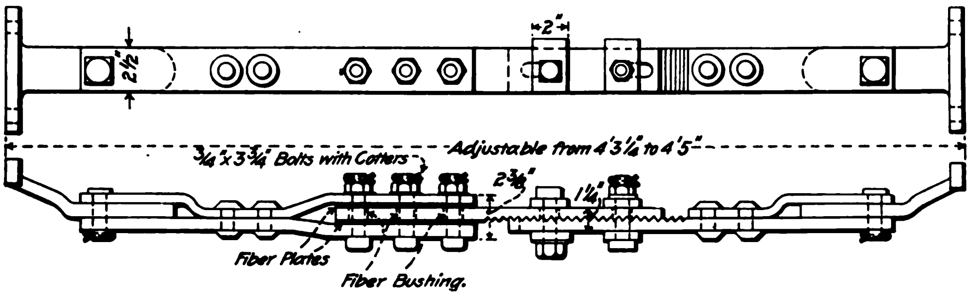


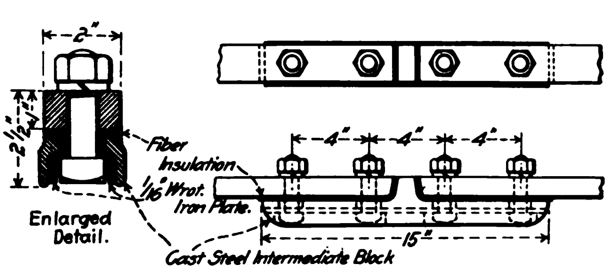
Fig. 2382. Method of Insulating Switch Rods and Tie Plates. Southern Pacific-Union Pacific.



Figs. 2383-2385. Insulated Switch Rod, with Lug for Throw Rod. Pennsylvania Railroad.

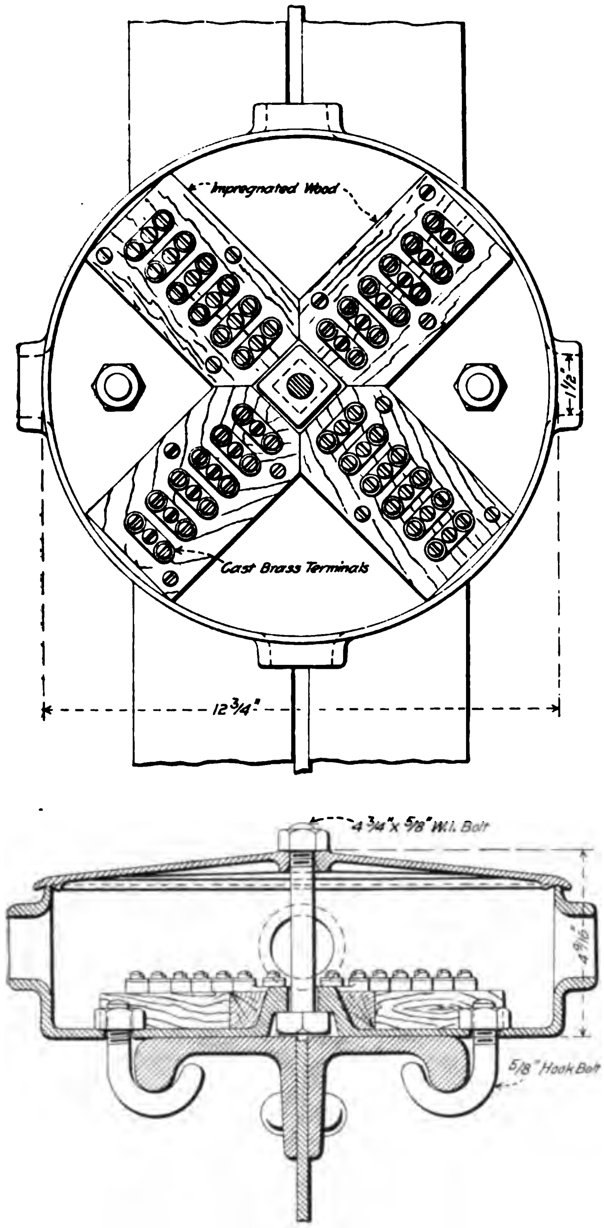


Figs. 2386-2387. Adjustable Insulated Switch Rod. Chicago, Milwaukee & St. Paul.

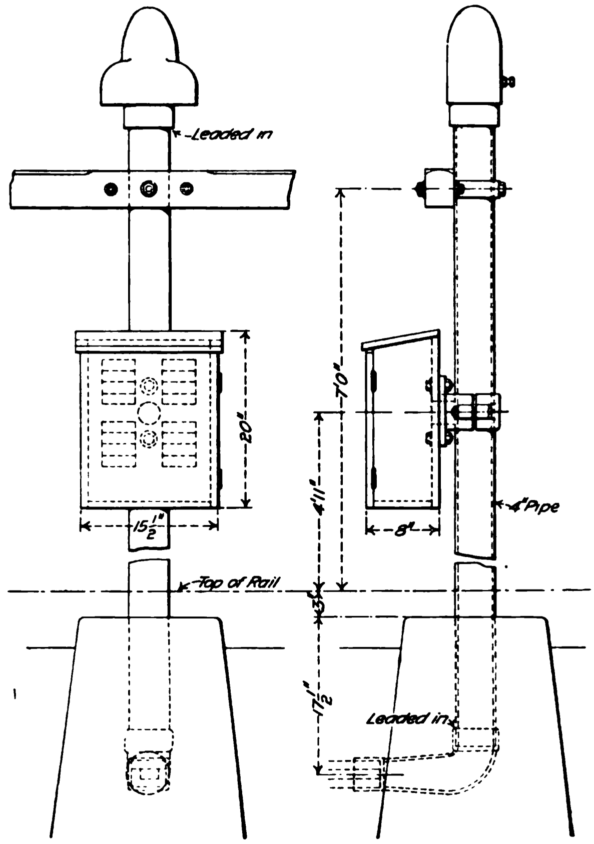


Figs. 2388-2390. Insulated Switch Rod and Details. Pennsylvania Railroad.

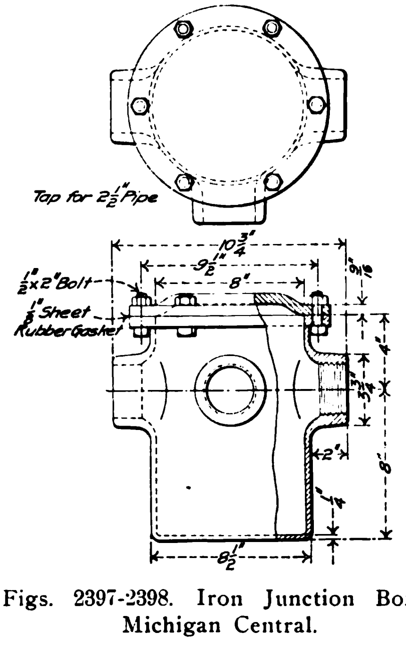
Fig. 2391. Axle Insulation for Hand Cars. Railroad Supply Company.



Figs. 2392-2393. Junction Box Attached to Pillar. Interborough Rapid Transit Company. The Union Switch & Signal Company.



Figs. 2395-2396. Junction Box on Iron Pipe Post, with Cross Arm. Lake Shore & Michigan Southern. The Union Switch & Signal Company.



Figs. 2397-2398. Iron Junction Box. Michigan Central.

Fig. 2394. Fuse and Junction Box. Railroad Supply Company.

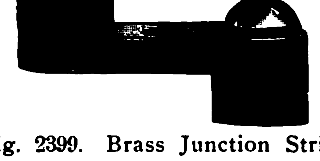
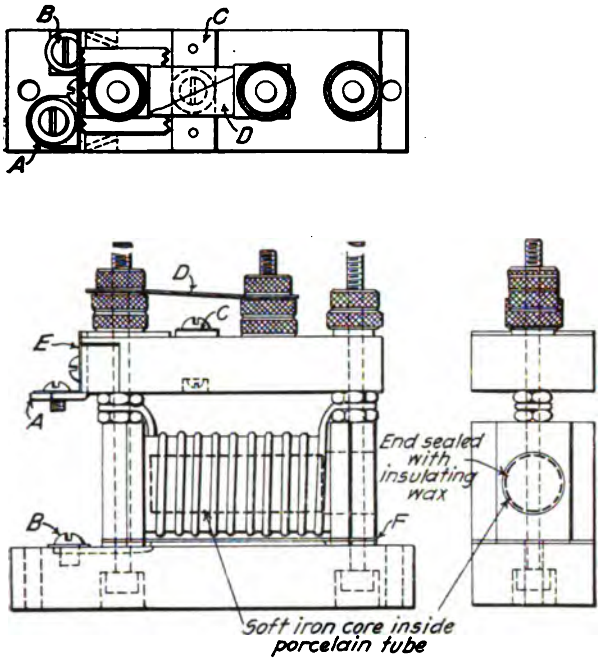
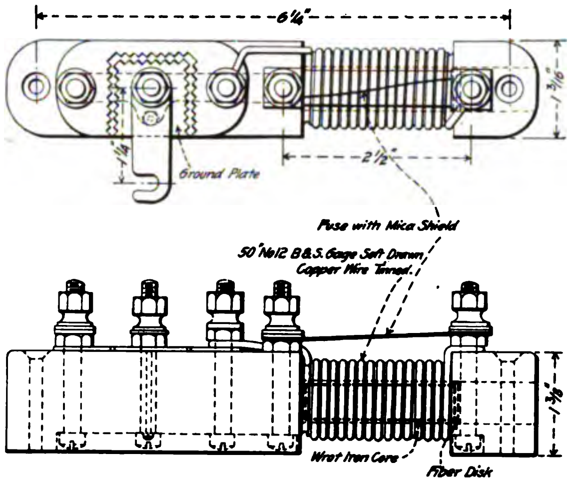


*Fig. 2399. Brass Junction Strip.

Letters Refer to List of Names of Parts Below.



Figs. 2400-2402. Lightning Arrester. Hall Signal Company.



Figs. 2403-2404. Lightning Arrester. Federal Signal Company.

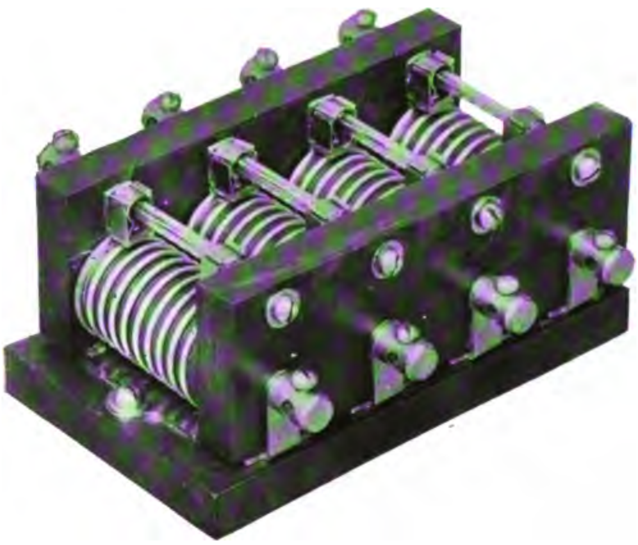


Fig. 2405. Lightning Arrester. General Electric Company.

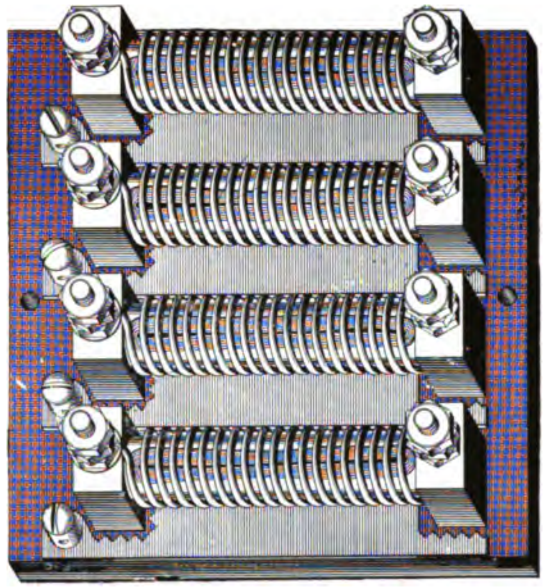


Fig. 2406. Four-Way Choke Coil Lightning Arrester. Railroad Supply Company.

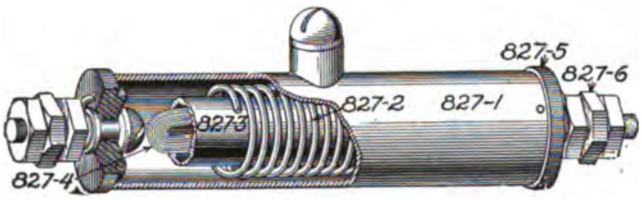


Fig. 2407. Part Sectional View of Enclosed Lightning Arrester. Railroad Supply Company.

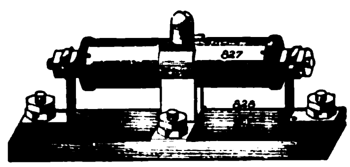
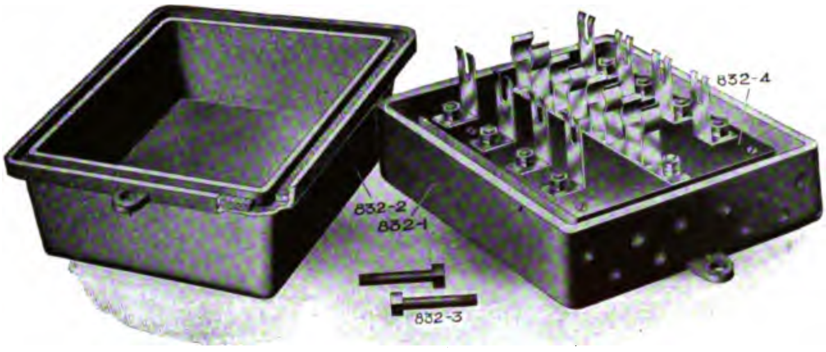


Fig. 2408. Enclosed Lightning Arrester Mounted on Slate Base. Railroad Supply Company.

Names of Parts, Hall Lightning Arrester; Figs. 2400-2402.

A *Saw Tooth with Lug for Connecting to Ground or Another Unit*
B *Ground Plate with Screw*
C *Ground Plate with Screw*
D *Fuse*
E *Mica Saw Tooth Cover*
F *Perforated Mica Ground Plate Cover*



Figs. 2409-2412. Cast Iron Box, with Slate Base for Enclosed Lightning Arresters. Railroad Supply Company.

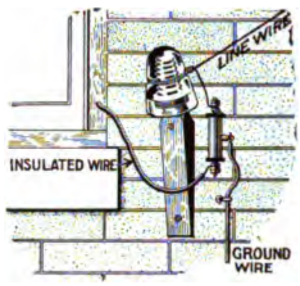


Fig. 2413. Application of Enclosed Lightning Arrester. Railroad Supply Company.

Fig. 2414. Carbon Lightning Arrester. Railroad Supply Company.

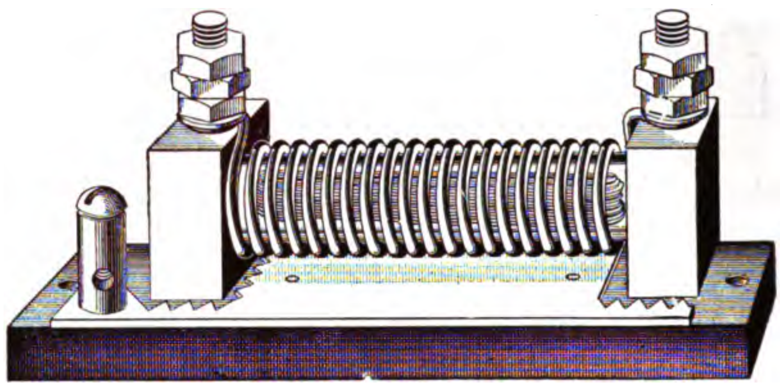


Fig. 2415. Choke Coil Lightning Arrester. Railroad Supply Company.

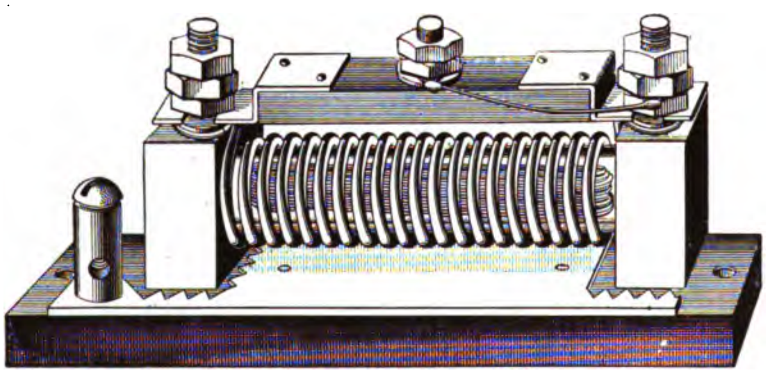


Fig. 2416. Choke Coil Lightning Arrester, with Fuse Block and Fuse. Railroad Supply Company.

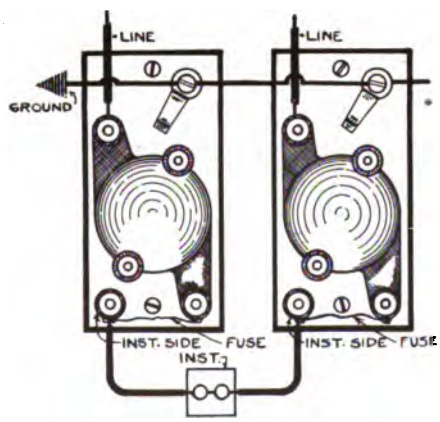


Fig. 2417. Carbon Lightning Arresters in Series with Instrument to be Protected. Railroad Supply Company.

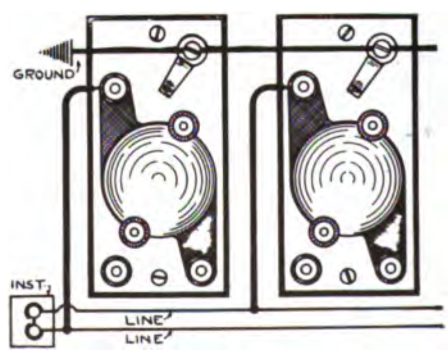
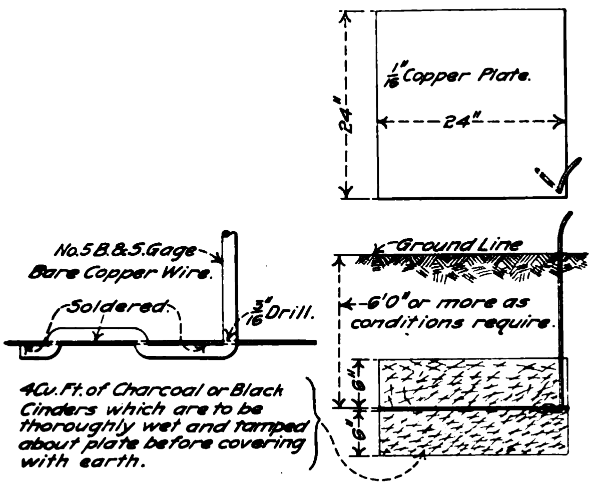


Fig. 2418. Carbon Lightning Arresters in Parallel with Line. Railroad Supply Company.

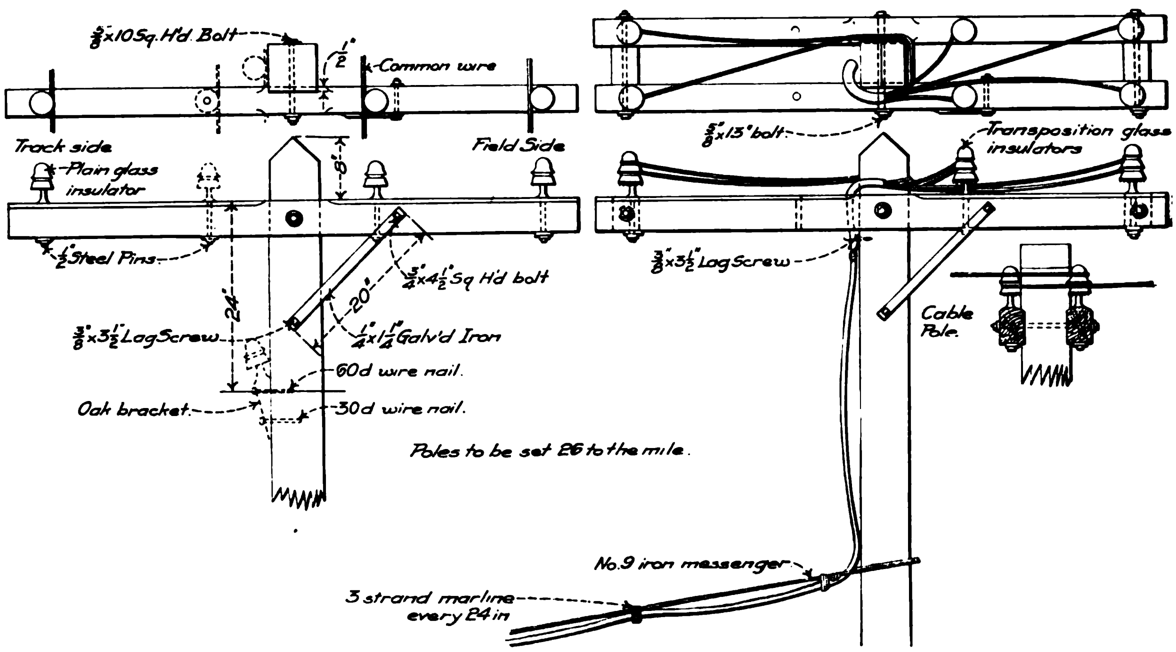
Figs. 2419-2422. Lightning Arrester. General Railway Signal Company.

Figs. 2423-2425. Details of Carbon Lightning Arrester. Railroad Supply Company.

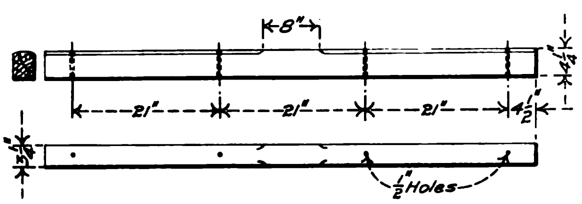


Figs. 2426-2428. Ground Plate and Details. Illinois Central.

Fig. 2429. Adjustable Pipe Ground Connection. General Electric Company.



Figs. 2430-2434. Details of Pole Line Construction and Wiring. Southern Pacific-Union Pacific.



Figs. 2435-2436. Standard Four-Pin Cross Arm. Southern Pacific-Union Pacific.

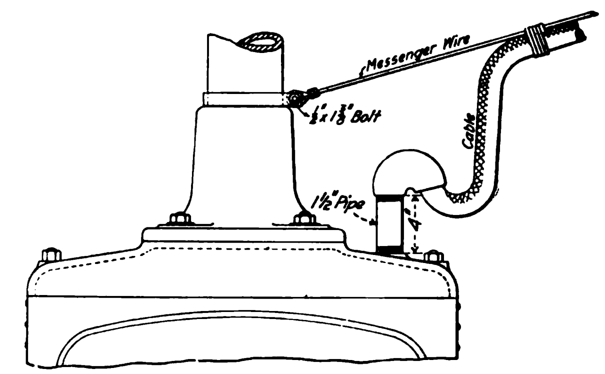
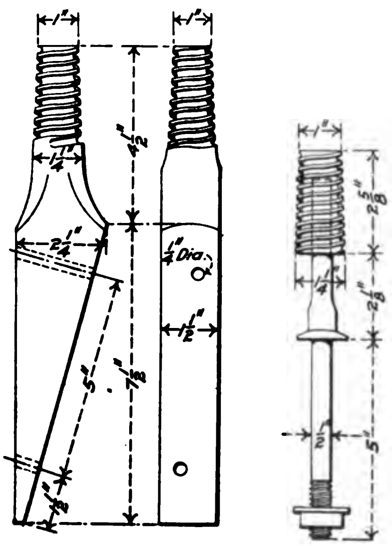
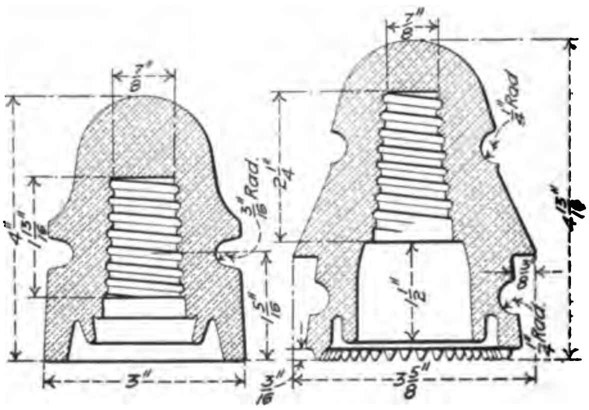


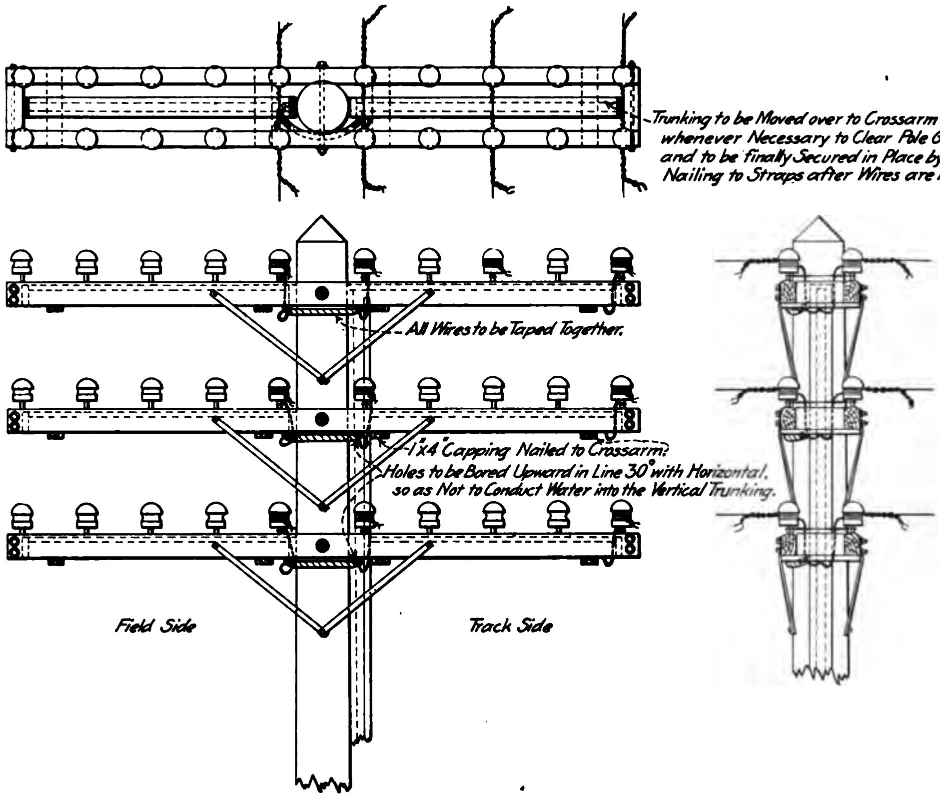
Fig. 2437. Method of Bringing Cable into Mechanism Case. Union Pacific.



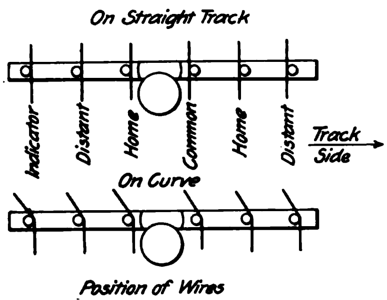
Figs. 2438-2440. Iron Pole Pin and Wooden Bracket. Southern Pacific.



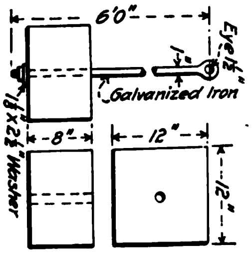
Figs. 2441-2442. Standard Glass Insulators. Southern Pacific-Union Pacific.



Figs. 2443-2445. Details of Pole Line Wiring and Construction. New York Central & Hudson River.



Figs. 2446-2447. Location of Signal Wires on Poles. Chicago & North-Western.



Figs. 2448-2450. Concrete Anchor Block for Pole Line. Chicago & North-Western.

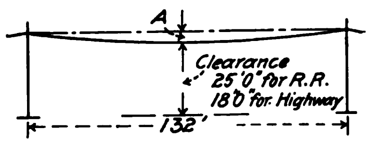
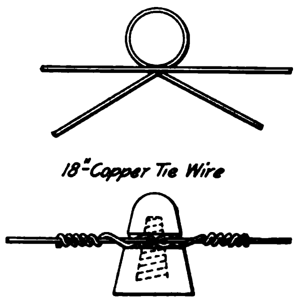
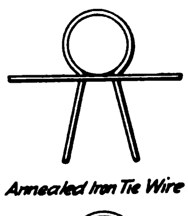


Fig. 2451. Standard Clearance for Line Wire. Chicago & North-Western.



Figs. 2454-2455. Method of Tying Copper Line Wire to Insulator. Chicago & North-Western.



Figs. 2452-2453. Method of Tying Iron Line Wire to Insulator. Chicago & North-Western.

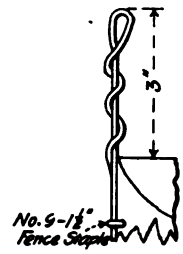
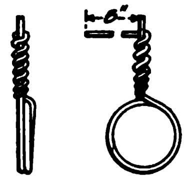


Fig. 2456. Pole Line Lightning Arrester. Chicago & North-Western.



Figs. 2457-2458. Line Wire Dead End. Chicago & North-Western.

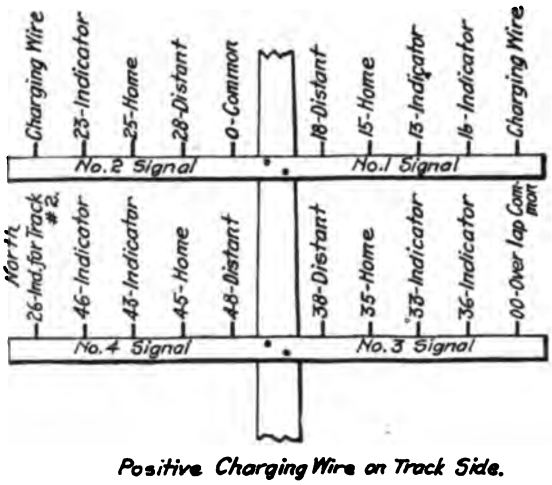


Fig. 2459. Standard Arrangement of Line Wires for Automatic Block Signals. Lake Shore & Michigan Southern.

Figs. 2460-2462. Wire Sleeve and Method of Making a Joint. Bryant Zinc Company.

*Fig. 2463. Insulating Tape.

Fig. 2464. Vertical Motor Generator Set. General Electric Company.

Fig. 2465. Generator. General Railway Signal Company.

Fig. 2466. Generator. General Electric Company.

Fig. 2467. Motor Generator, Three-Phase Motor. General Electric Company.

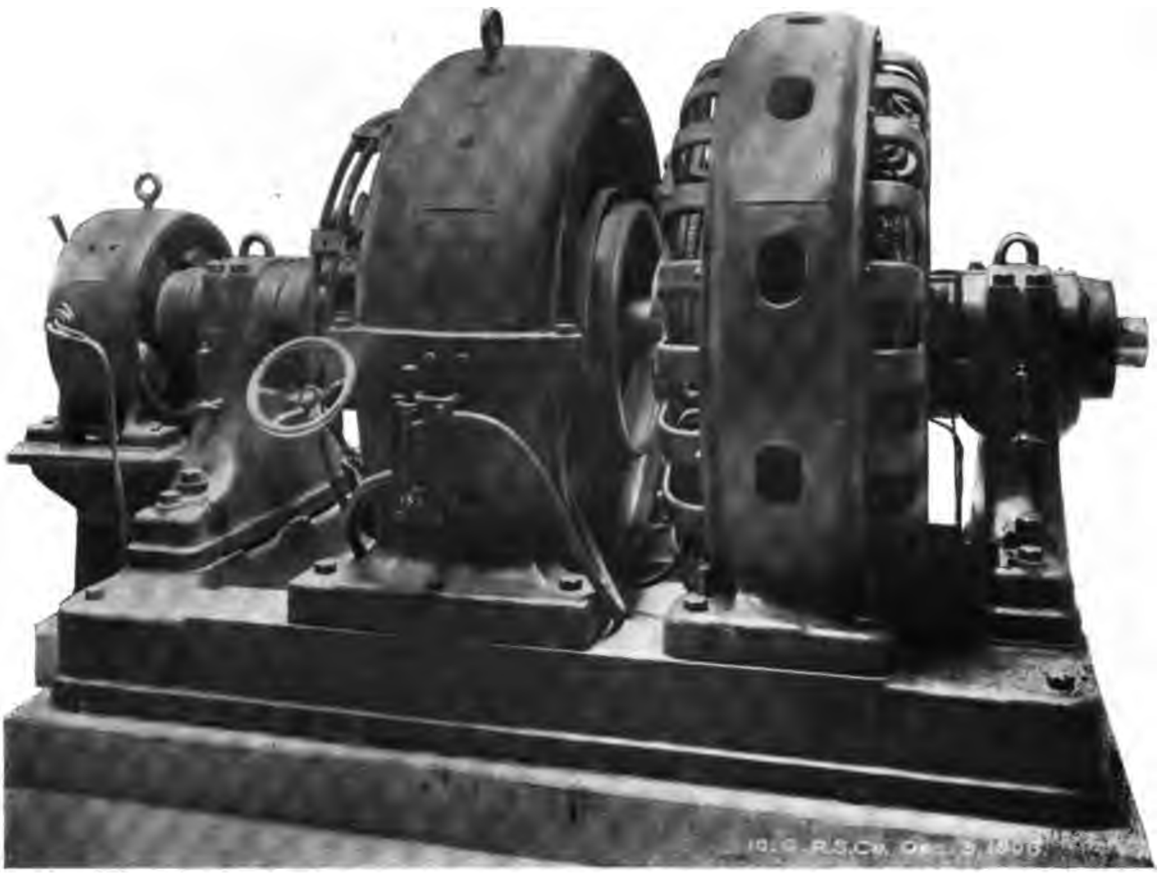


Fig. 2468. Motor Generator Set for Sub-Station as Furnished for the Electric Zone of the New York Central & Hudson River by the General Railway Signal Company.

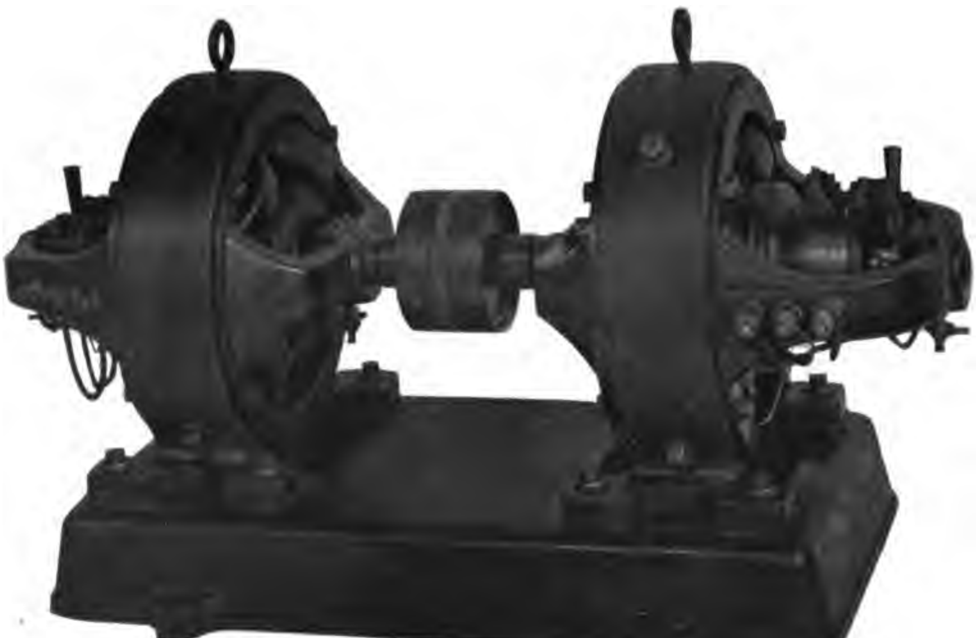


Fig. 2469. Motor Generator Set for Electric Interlocking Plant. General Railway Signal Company.

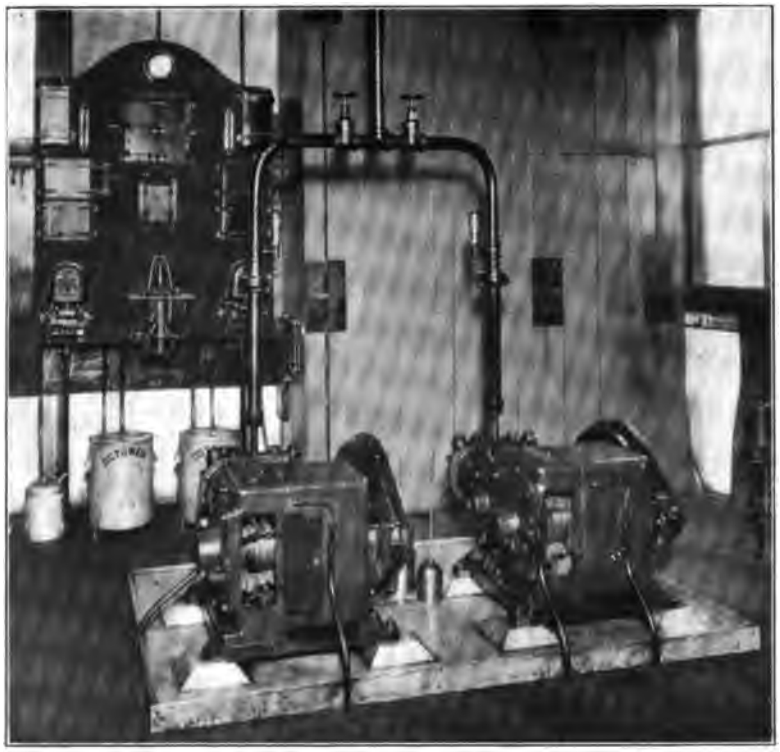


Fig. 2470. Motor-Driven Air Compressors for Electro-Pneumatic Interlocking Plant at East New York. Brooklyn Rapid Transit Company. The Union Switch & Signal Company.

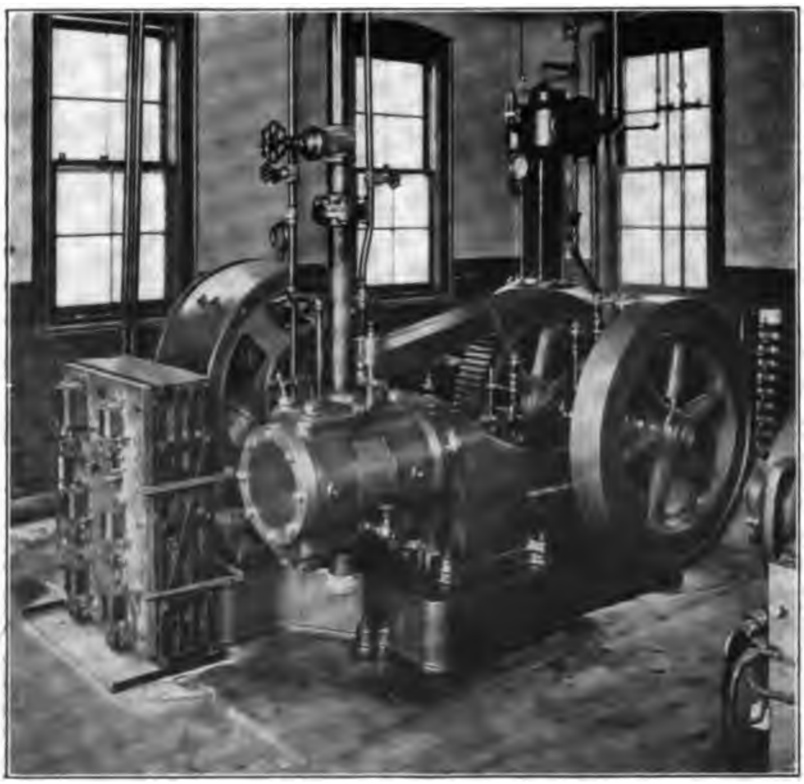


Fig. 2471. Motor-Driven Ingersoll-Rand Air Compressor for Electro-Pneumatic Interlocking Plant at St. George. Baltimore & Ohio. The Union Switch & Signal Company.

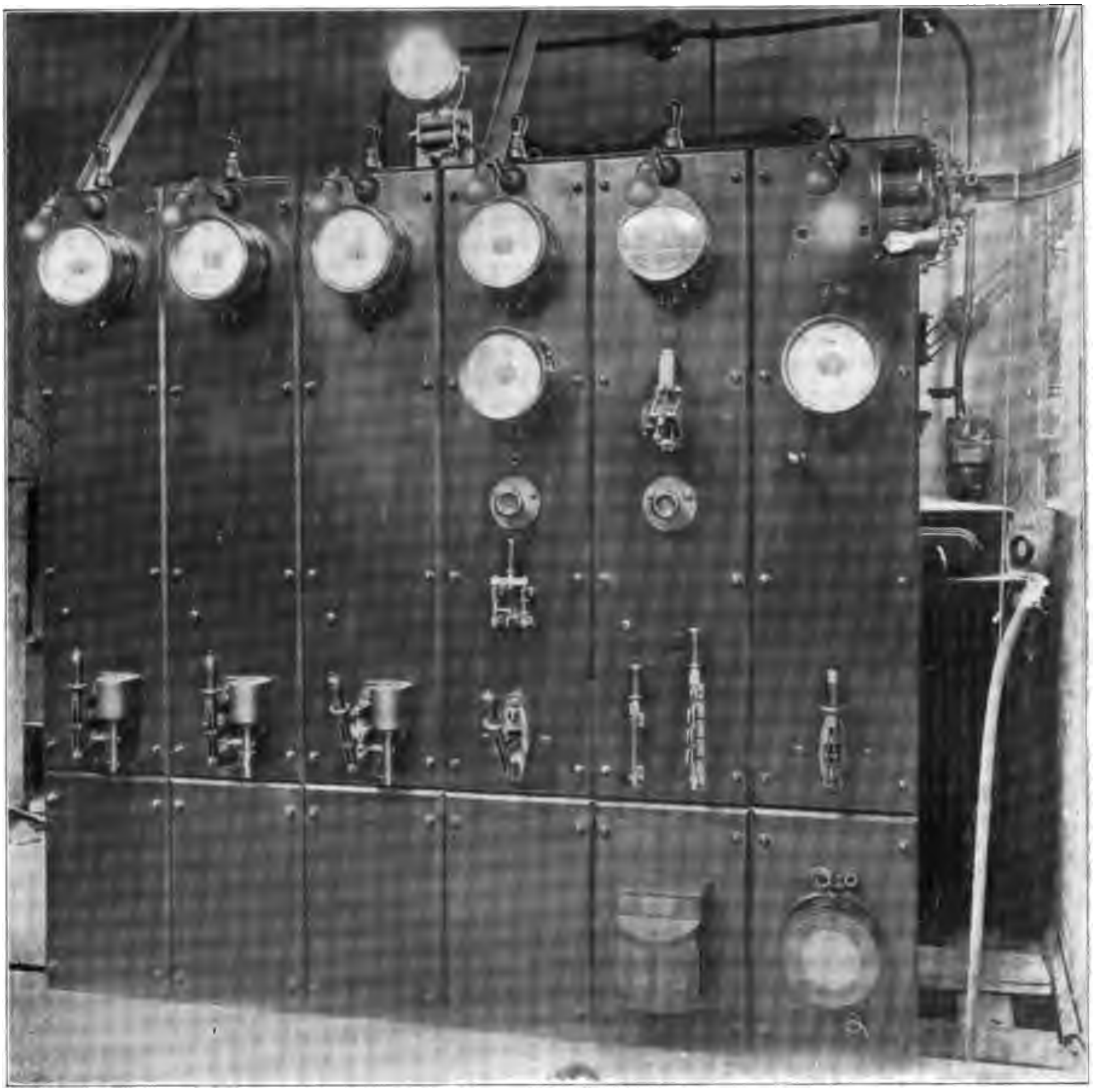


Fig. 2472. Switchboard for Sub-Station as Furnished for the Electric Zone of the New York Central & Hudson River by the General Railway Signal Company.

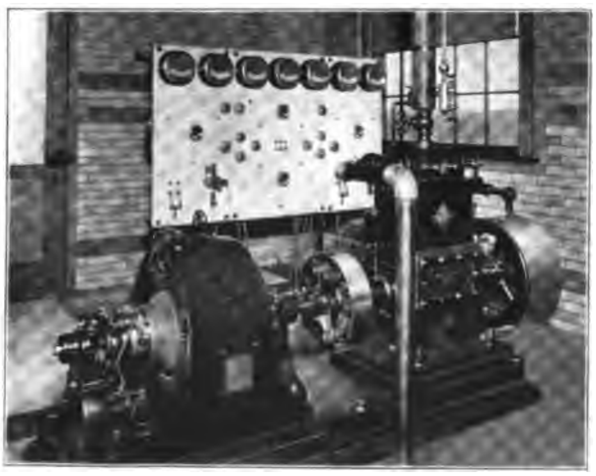
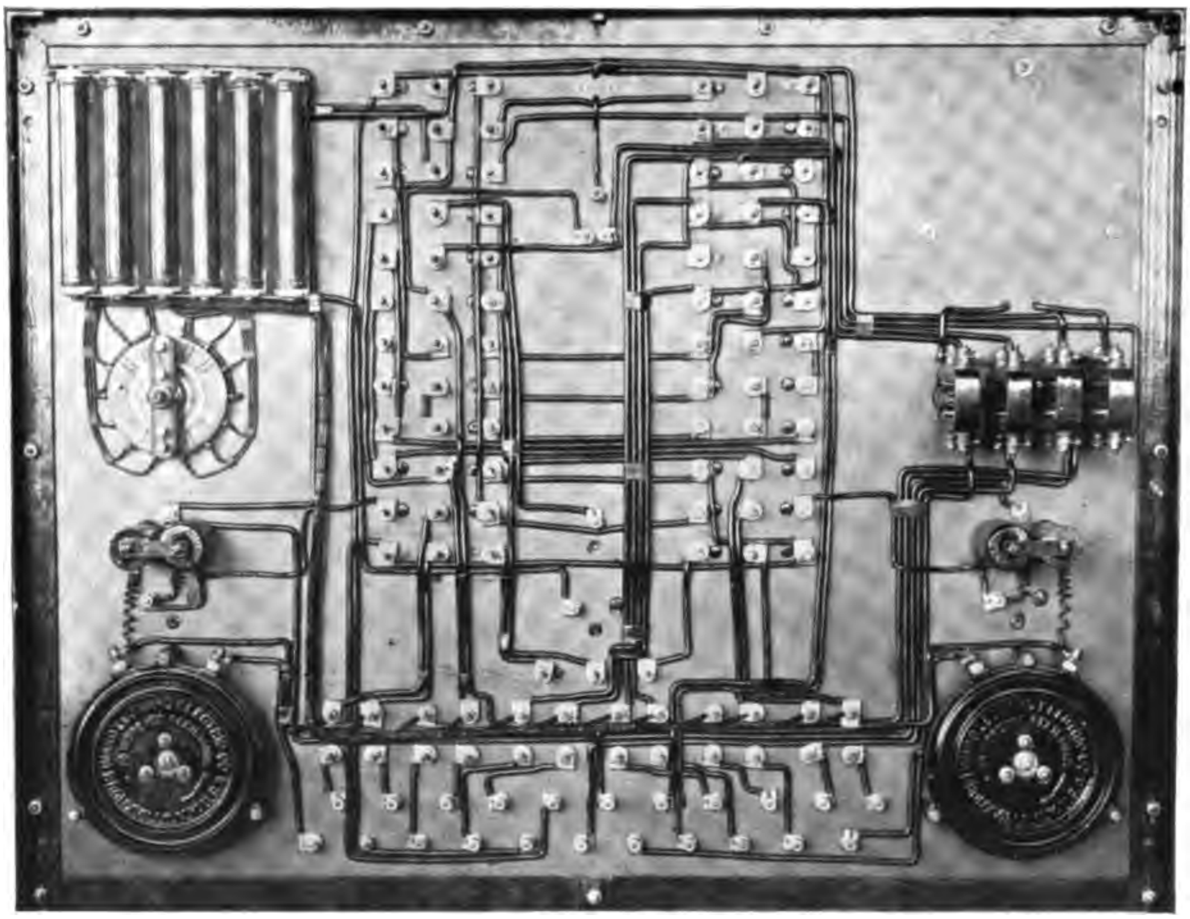


Fig. 2473. Interlocking Plant Power Room Equipment. Pennsylvania Railroad.

Fig. 2474. Interlocking Plant Power Room Equipment. Southern Pacific.



Figs. 2475-2476. Front and Rear Views of Power Switchboard. General Railway Signal Company.

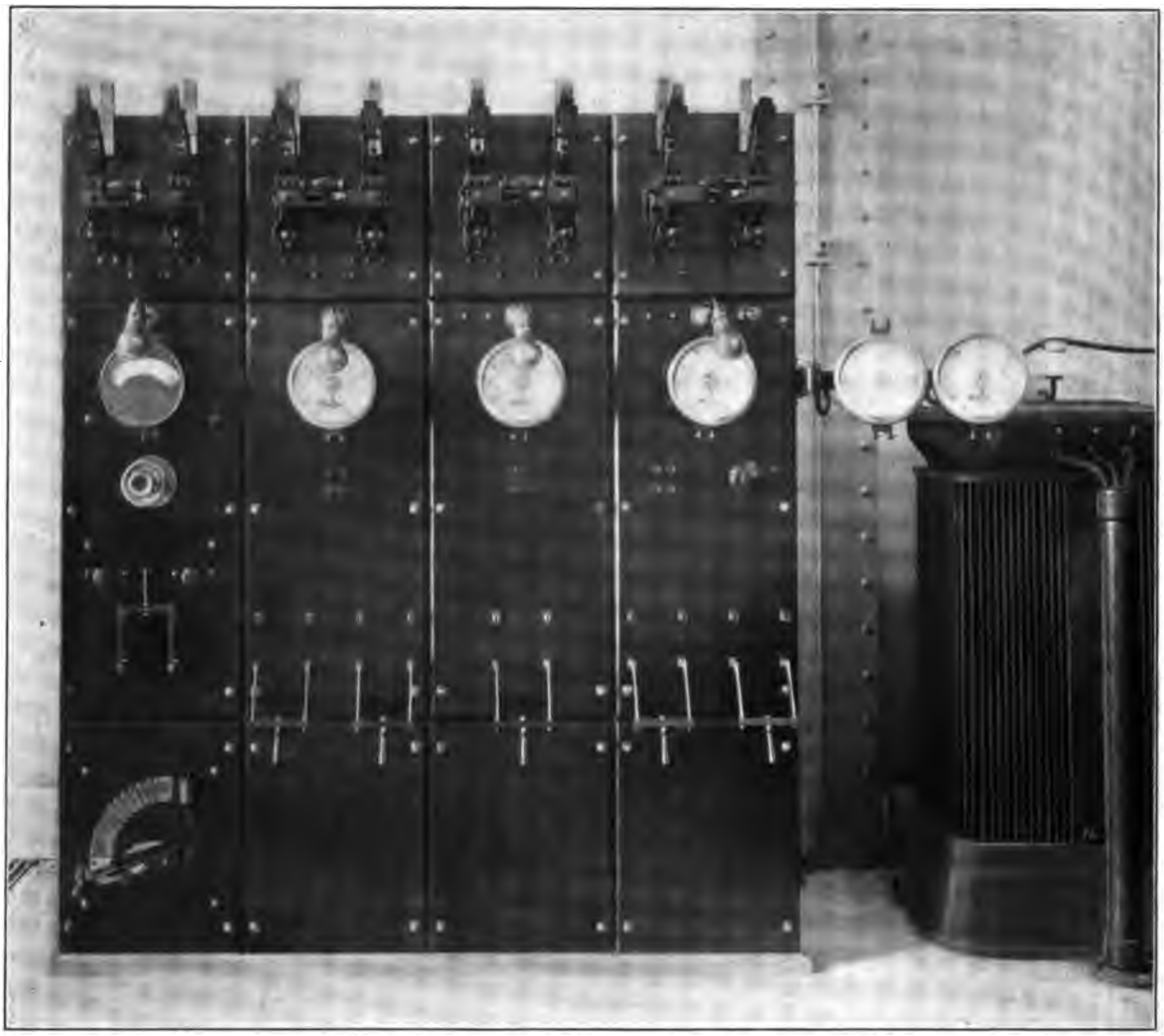


Fig. 2477. Switchboard for Alternating Current Track Circuit Block Signal System. Interborough Rapid Transit Company. The Union Switch & Signal Company.

Fig. 2478. Chloride Accumulator Type, Portable Storage Batteries in Charging Station. Southern Pacific.

Fig. 2479. Ward Leonard Switchboard Resistance Unit, Showing Bare Wire and Complete Unit. Ward Leonard Electric Company.

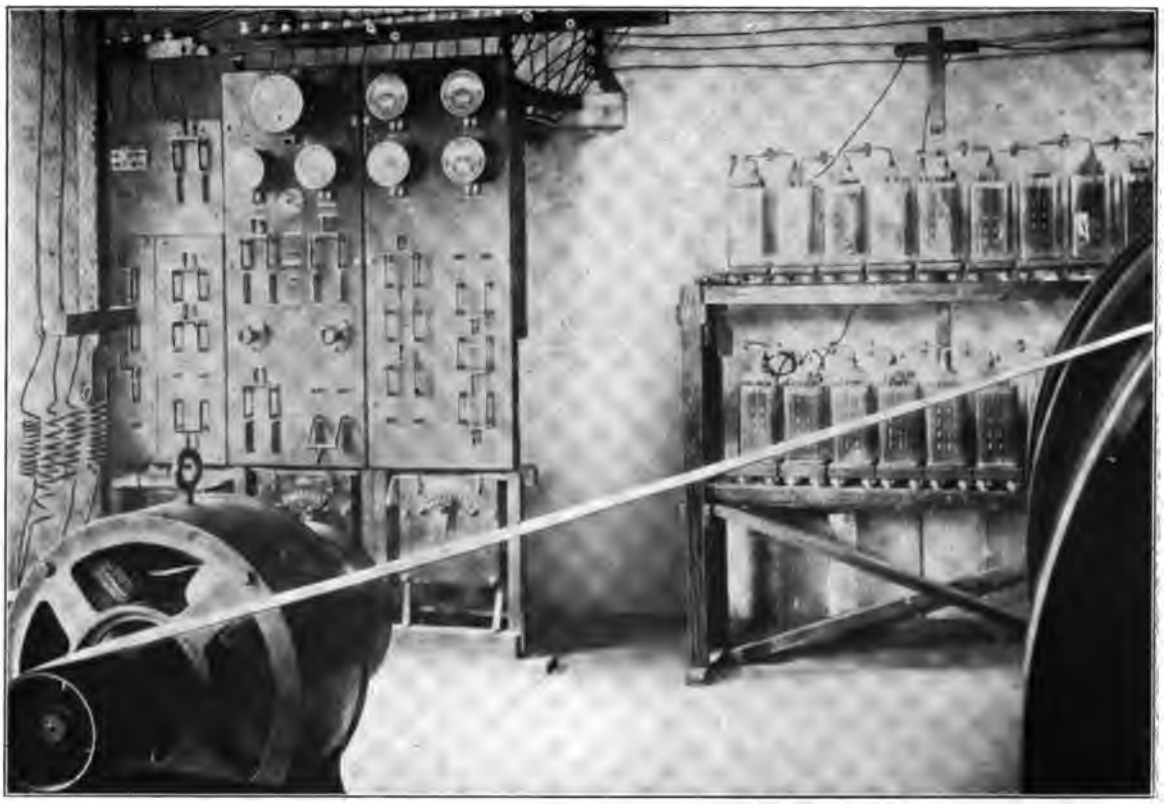


Fig. 2480. Power Room for Electric Interlocking Plant. Federal Signal Company.

Fig. 2481. Motor-Driven Air Compressors and Control Switchboards for Electro-Pneumatic Interlocking Plant. Baltimore & Ohio. The Union Switch & Signal Company.

Fig. 2482. Power Switchboard Panel. General Railway Signal Company.

Fig. 2483. High Tension Pole and Line. New York Central & Hudson River. See Fig. 1795.

THE MERCURY ARC RECTIFIER

The mercury arc rectifier consists, as its name implies, of a mercury vapor arc. This arc is enclosed in an exhausted glass vessel of peculiar construction, which can be seen in the center of the switchboard, Figs. 2487-2496.

Mercury vapor in its ordinary or molecular condition is practically a non-conductor of electricity. Such vapor might be formed by applying heat to a mass of mercury enclosed in a vacuous chamber. If a body of vapor thus formed were subjected to the action of an electromotive force, either continuous or alternating, its resistance would be found to be very great. If, however, the mercury vapor is ionized, in other words, if the atoms of mercury in this vapor are electrified, the electrical resistance to current in one direction will be very small, while its resistance to current in the opposite direction will still be great. To use a very crude analogy, its action on an electric current is similar to the action of a check valve on a current of water flowing through a pipe.

The ionization of mercury vapor is easily accomplished. If an arc is formed between one mercury electrode and another electrode, the mercury being the negative, ionized mercury vapor will result. When a mercury arc is formed, as in the mercury arc lamp, the negative electrode being mercury, the resistance of this arc is small, but only to current of one direction. Hence it is seen that the current in a mercury arc must be uni-directional. This brings us to an understanding of the action of the rectifier. A mercury cathode is provided and two anodes of suitable material are connected across the terminals of an alternating current circuit, thus becoming alternatively positive and negative. The arc shifts from one anode to the other with each alternation, always passing from a positive anode to the negative cathode. The current in the wire connected to the cathode is, therefore, always in the same direction.

The direct current delivered by the mercury arc rectifier is very different in its characteristics from that delivered by a synchronously driven rectifier. The current from a synchronously driven machine consists of a series of pulsations, each separated from the others by a certain small interval. If we were able to operate a mercury arc rectifier, in accordance with the above theo-

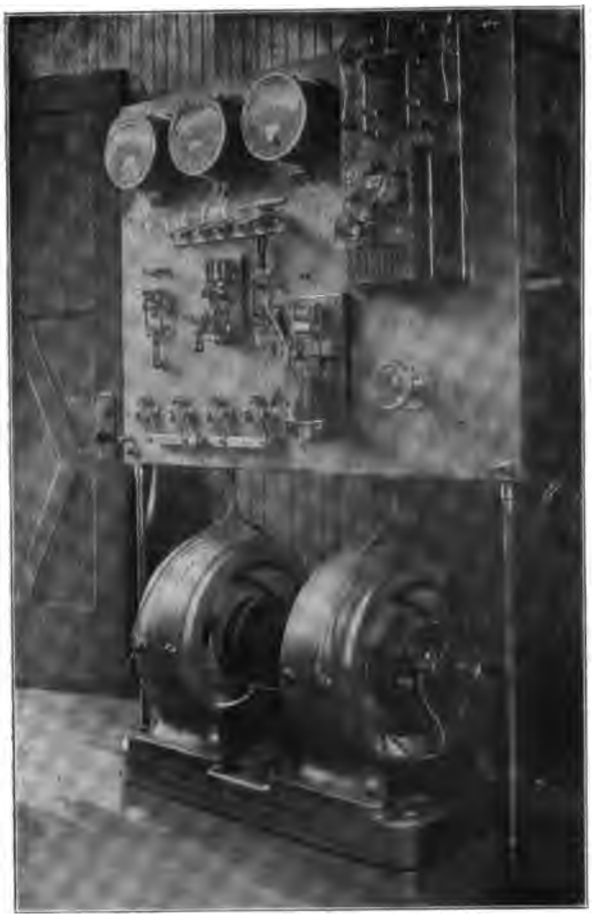


Fig. 2484. Switchboard and Motor Generator Set. Boston Elevated.

Fig. 2485. Switchboard for Electric Interlocking Plant. New York, New Haven & Hartford. The Union Switch & Signal Company.

retical considerations, without any accessory apparatus, this rectified current would be composed of a series of pulsations, but without the separating gaps mentioned, the current wave being similar in form to the impressed alternating current wave, except that the negative half would be transposed, so as to become positive with reference to the zero line. This, however, is not the case.

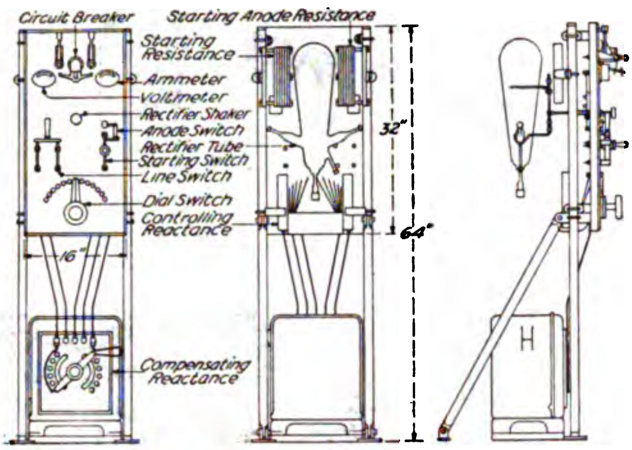
If, when a mercury arc is once established, the current falls to zero, even for the most minute interval of time, the arc is extinguished, and certain means are necessary for its re-establishment. It is, therefore, necessary to insure that the current through the mercury arc rectifier shall not fall to zero, and so cause an interruption of the arc. The means used to bring about this result are reactances introduced in the circuit of the rectifier and so designed as to obliterate the pulsations, so far as needful, and make the resulting current continuous.

Bearing in mind the fact that the current flow through mercury vapor must always be in the same direction, a clear understanding of the mercury arc rectifier may be secured by a study of the diagram, Fig. 2496. In this diagram A and A' are the operating anodes; B is the cathode; C is the starting anode; E and F are reactance coils and G and H are the terminals of the alternating current supply. The battery to be charged is connected between cathode B and the point D between the two reactance coils. The rectifier is supported by a movable frame, so arranged that the top of the tube may be tilted slightly in starting. This movement of the tube forms a bridge of mercury between the cathode B and the starting anode C, and current may then flow between them through the mercury. When the tube swings into its normal position, this bridge is broken, and an arc of ionized mercury vapor is formed. This ionized vapor, ascending in the tube to the anodes A and A', permits a flow of current from each of them in turn to the cathode B, and the tube is then in operation through a starting resistance. The load switch is then closed and the starting anode and the starting resistance are both disconnected by opening the starting switch. Automatic starting devices have been used to some extent, but the operation of starting, as above described, is so extremely simple that the necessary complications incident to the use of automatic devices are not considered advisable, except in special cases.

From inspection of Fig. 2496 it will be seen that the alternating current circuit is through the mercury arc, the battery and one of the reactance coils, one-half of the wave being through the anode

Fig. 2486. Storage Batteries in Battery Case at Base of Bracket Post. Pennsylvania Railroad.

at the right and the reactance at the left of the diagram, while the other half wave flows through the anode at the left and the reactance at the right. When the impressed e.m.f. falls below that required to overcome the counter e.m.f. of the mercury arc (about 14 volts) plus the load, the reactance which has been receiving current from the line, discharges, maintaining a current in the same direction. This action maintains the excitation of the anode, and prevents the current from approaching the zero value until the



Figs. 2487-2488. Mercury Arc Rectifier and Operating Board. General Electric Company.

Fig. 2489. Front View of Mercury Arc Rectifier Operating Board. General Electric Company.

Fig. 2490. Rear View of Fig. 2489.

Figs. 2491-2493. Control Apparatus for Mercury Arc Rectifier. General Electric Company.

Fig. 2494. Mercury Arc Rectifier Mounted on Operating Board, Front View. General Electric Company.

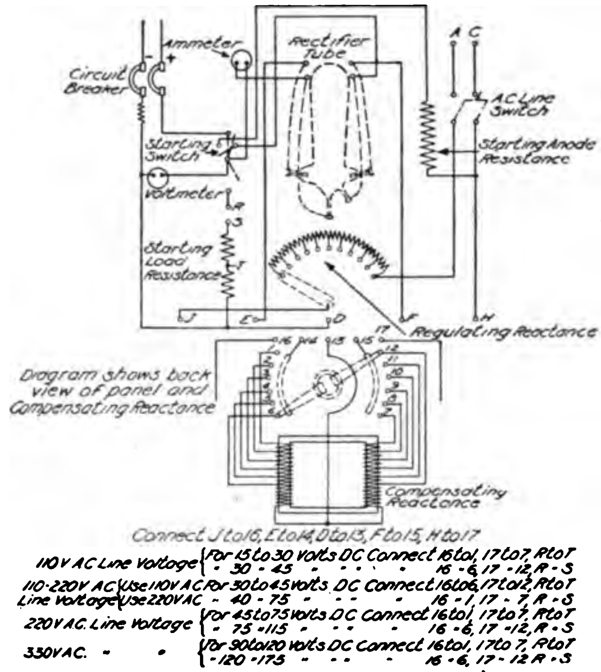


Fig. 2495. Control and Operating Circuits for Mercury Arc Rectifier. General Electric Company.

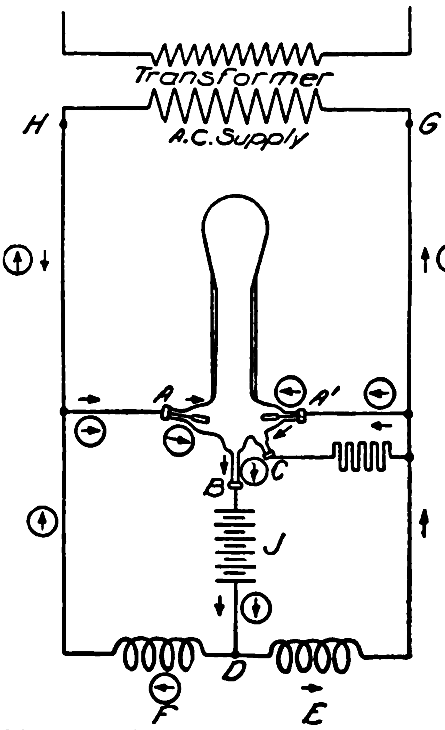


Fig. 2496. Control and Operating Circuits for Mercury Arc Rectifier.

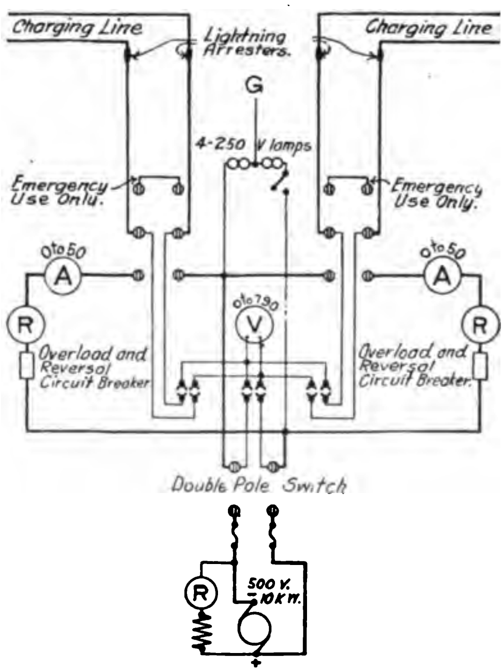


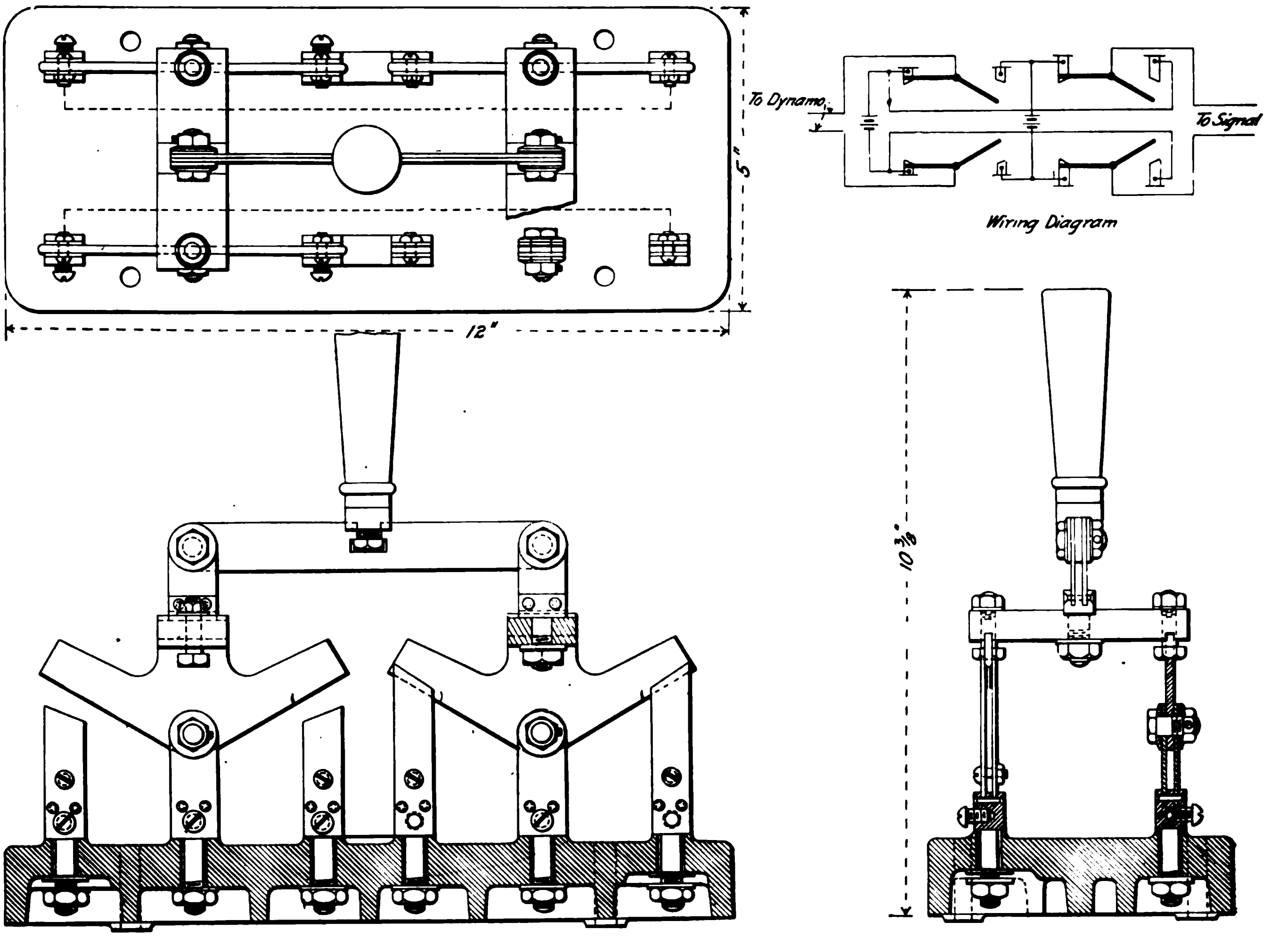
Fig. 2497. Switchboard and Charging Circuits at Power House. Lake Shore & Michigan Southern.

voltage at the other anode has risen to a point where an arc is started between it and the cathode. To make this action more plain, the path of the current through the battery, due to one side of the wave, has been shown in plain arrow heads, while that due to the other half of the wave is indicated by the arrow heads in circles.

POWER SUPPLY CIRCUITS

NEW YORK, ONTARIO & WESTERN

Fig. 2507 is a diagram of circuits and apparatus for supplying electric power to the electro-pneumatic interlocking plant at Fallsburgh Tunnel, on the New York, Ontario & Western, where double track converges into single track through the tunnel and one plant controls the switches and signals at both ends. Current is normally furnished by one of the air-driven generators, supplied with air from the switch and signal mains. One generator is held in reserve and a primary battery is also installed of sufficient capacity to operate the plant should both generators break down at the same time. Indicator A is controlled by a track circuit through the tunnel. It has a stick wiring (not shown) so arranged that after the train enters the section with a clear signal, the indicator cannot pick up until the train has left the section and the signal has been restored to the normal position. As shown the indicator breaks all signal control circuits. The relay B is also controlled by the indicator, and in turn controls lock circuits for the various functions.



Figs. 2498-2501. Storage Battery Charging Switch. The Union Switch & Signal Company.

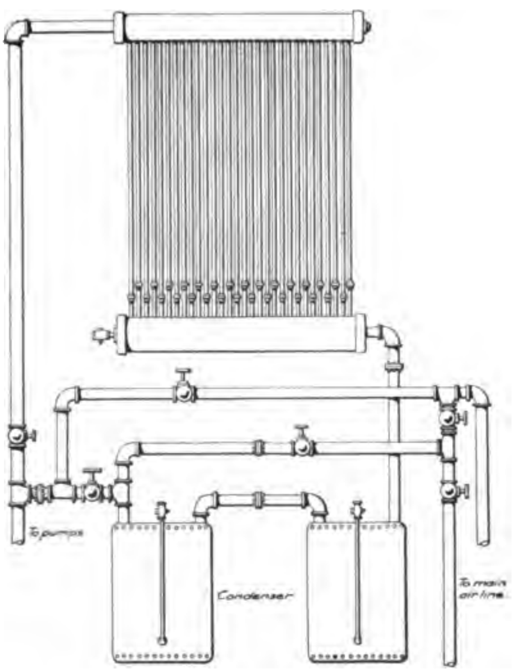


Fig. 2502. Cooling Coils and Drip Tanks for Electro-Pneumatic Interlocking Plant. New York, Ontario & Western.

*Fig. 2503. Copper Terminal Mica Enclosed Fuse.

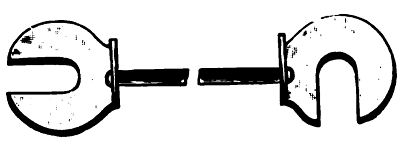


*Fig. 2504. Copper Terminal Fuse.

Fig. 2505. Fuse Plug. Central Electric Company.

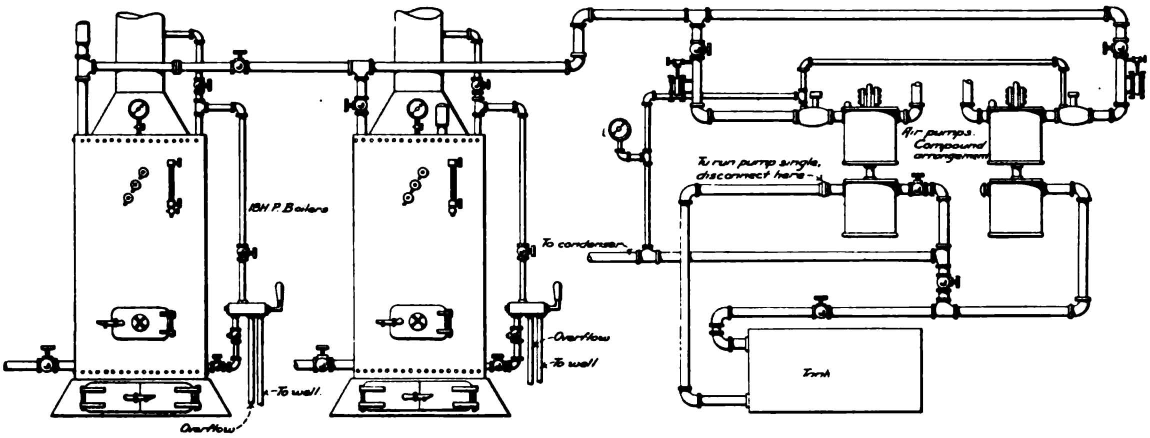


Fig. 2506. Air Compressor Plant Using Air Brake Apparatus. New York, Ontario & Western.

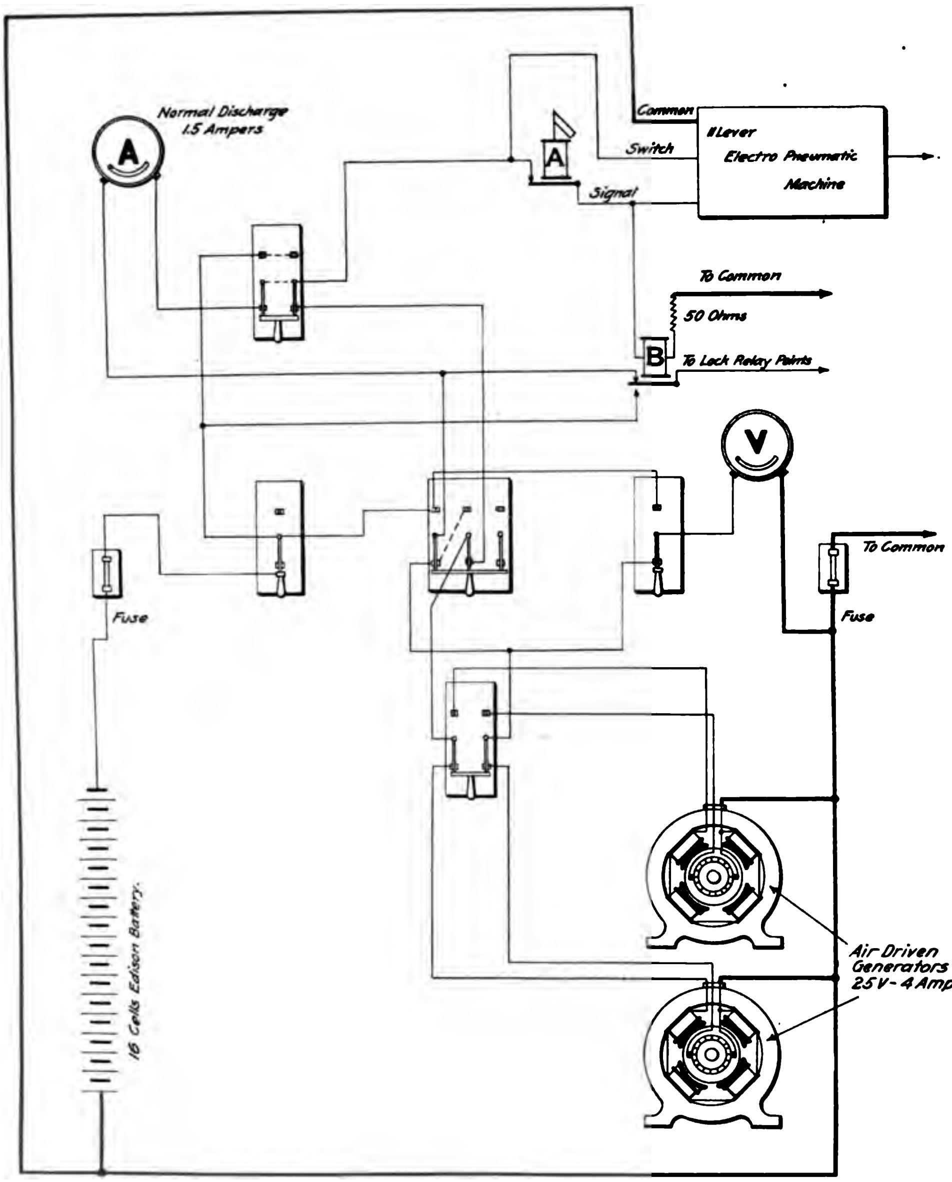


Fig. 2507. Circuits for Power Supply, Electro-Pneumatic Interlocking Plant. New York, Ontario & Western.

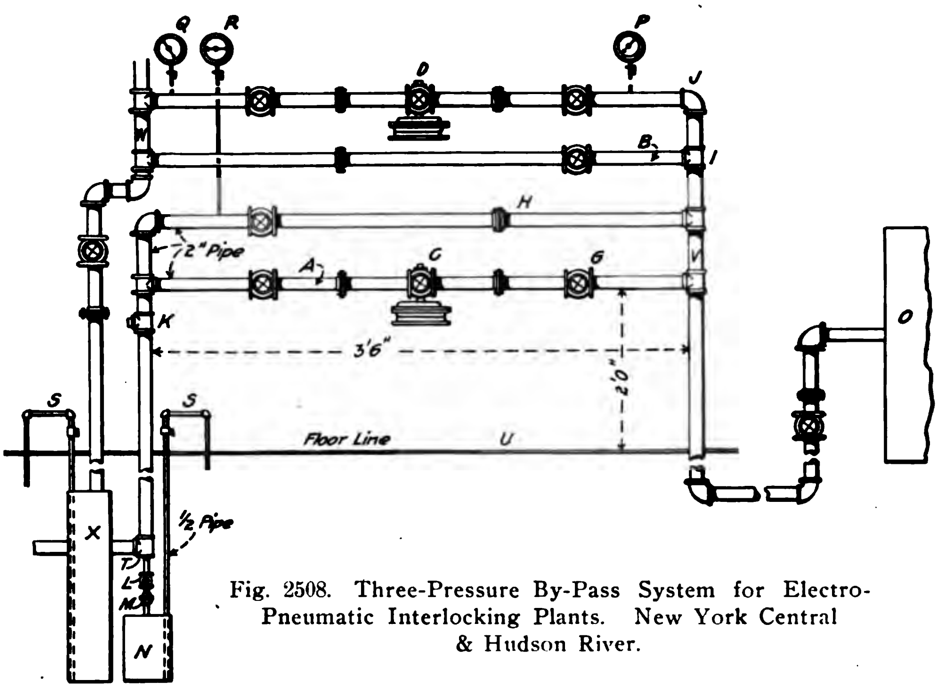


Fig. 2508. Three-Pressure By-Pass System for Electro-Pneumatic Interlocking Plants. New York Central & Hudson River.

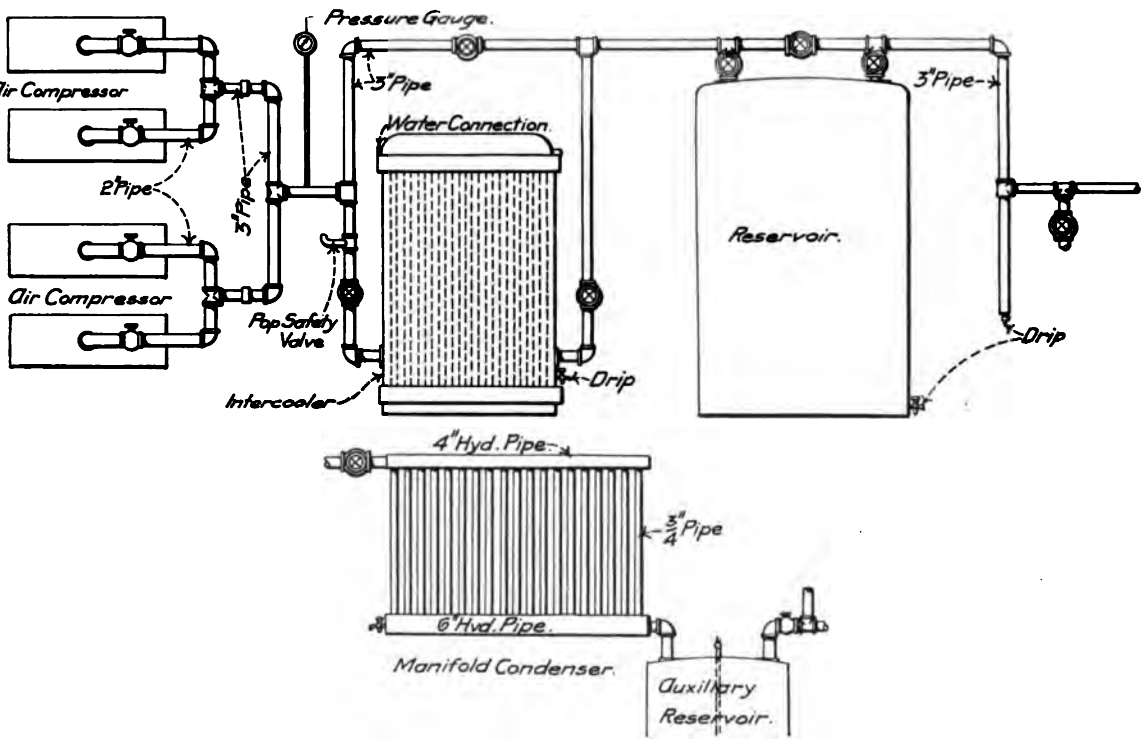
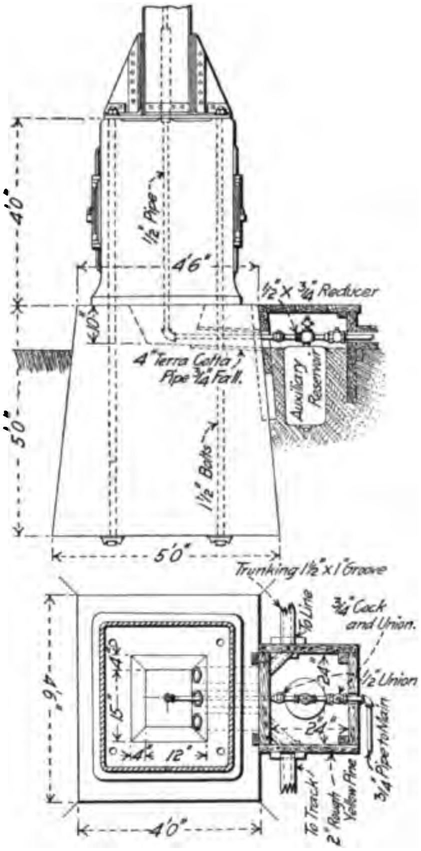


Fig. 2509. Standard Connections to Air Compressors, Water Cooler, Air Reservoir, Cooling Coils and Auxiliary Reservoir for Electro-Pneumatic Interlocking Plant. New York Central & Hudson River.

Names of Parts for Three-Pressure By-Path System; Fig. 2508.

A *High Pressure Line*
B *Intermediate Pressure*
C *High Pressure Foster Reducing Valve*
D *Low Pressure Foster Reducing Valve*
E *H. P. By-Path*
F *L. P. By-Path*
G *2" Globe Valves*
H *2" Flange Unions*
I *2" T's*
J *2" L's*
K *2" x 2" x ¾" T's for Hose Connections*
L *1" Globe Valve*
M *1" Union*
N *Drip Tank or Reservoir*
O *Intermediate Pressure Storage Tank*
P *I. P. Gauge*
Q *L. P. Gauge*
R *H. P. Gauge*
S *Siphon Pipe*
T *2" x 1" x 2" T*
U *Floor Line*
V *2" x 6" Nipples*
W *2" x 7½" Nipples*
X *L. P. Storage Tank*



Figs. 2510-2511. Method of Supplying Air to Electro-Pneumatic Signals on Bracket Post. Pennsylvania Railroad.

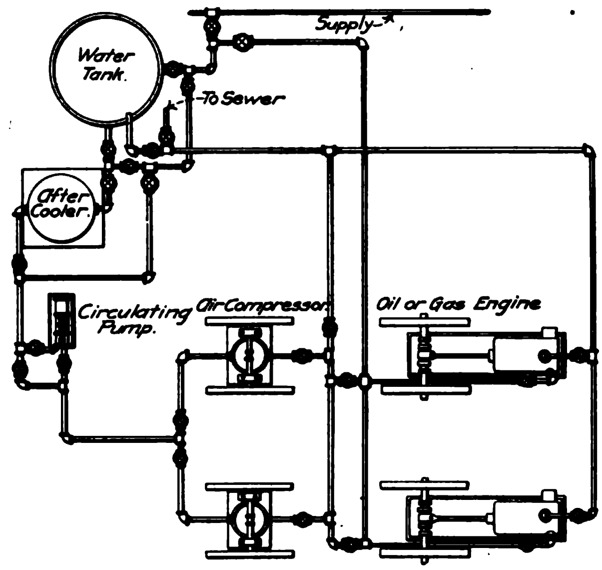
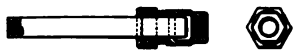


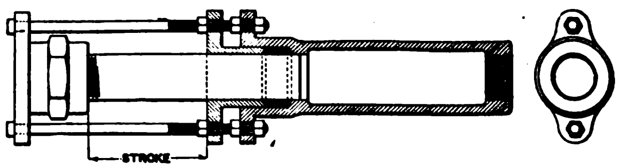
Fig. 2512. Standard Piping and Water Cooling Connections for Air Compressor Plants. New York Central & Hudson River.

Fig. 2513. Elevated Railroad Type of Auxiliary Reservoir. The Union Switch & Signal Company.



Figs. 2514-2515. Expansion Joint for Condenser. The Union Switch & Signal Company.

Fig. 2516. Hose Connection with Union. The Union Switch & Signal Company.



Figs. 2517-2518. Expansion Joint for Air Pipe. The Union Switch & Signal Company.

Fig. 2519. Auxiliary Reservoir. The Union Switch & Signal Company.

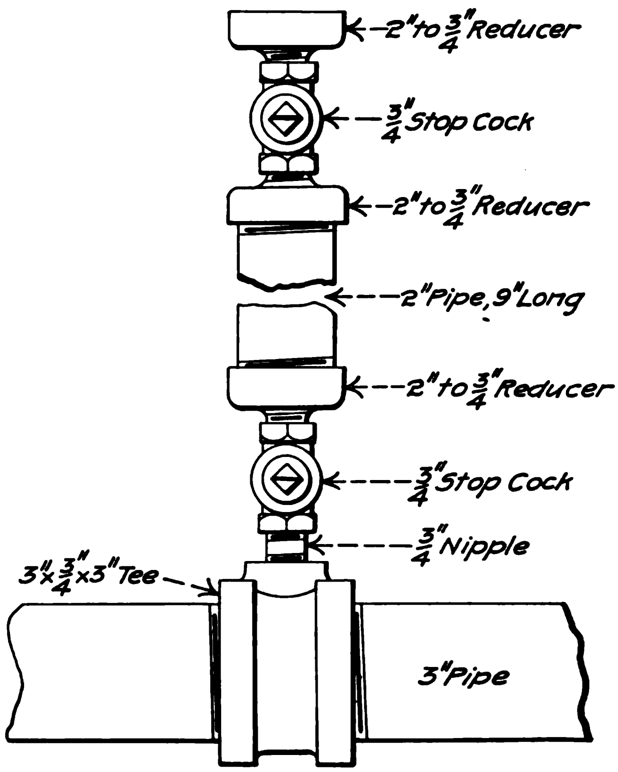


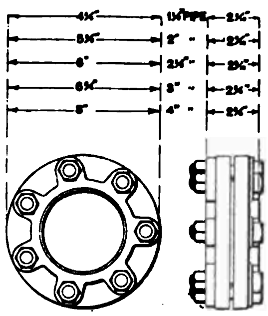
Fig. 2520. Alcohol Inlet Valve for Air Pipe. New York Central & Hudson River.

Fig. 2521. Main Reservoir.

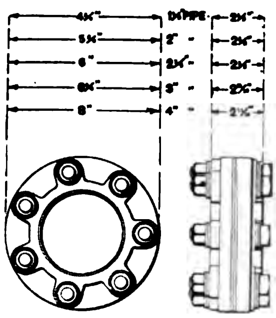
Fig. 2522. Auxiliary Reservoir.

Fig. 2523. Auxiliary Reservoir and Dwarf Signal Foundation Combined.

Figs. 2521-2523. Reservoirs. The Union Switch & Signal Company.



Figs. 2524-2525. Flange Union.



Figs. 2526-2527. Insulated Flange Union.

Figs. 2524-2527. Unions. The Union Switch & Signal Company.

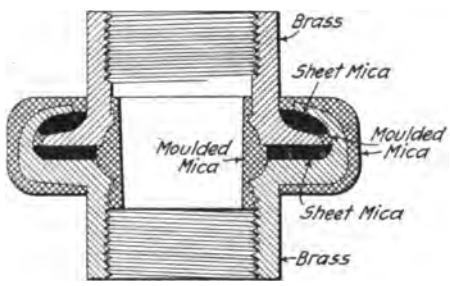


Fig. 2528. Pipe Insulation. H. W. Johns-Manville Company.

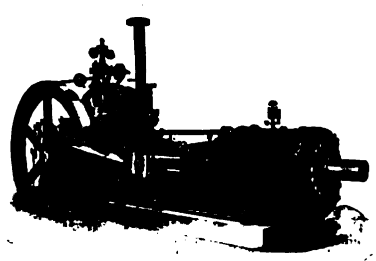


Fig. 2529. Ingersoll-Sergeant "Class A-I" Air Compressor.

Figs. 2530-2532. Pipe Unions with Ground Brass Seats. National Tube Company.

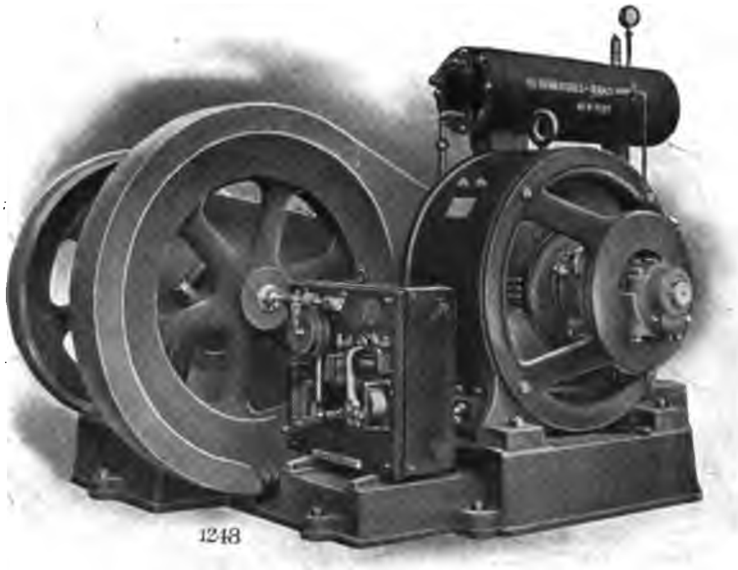


Fig. 2533. Ingersoll-Sergeant Motor-Driven Air Compressor. Interborough Rapid Transit Company.

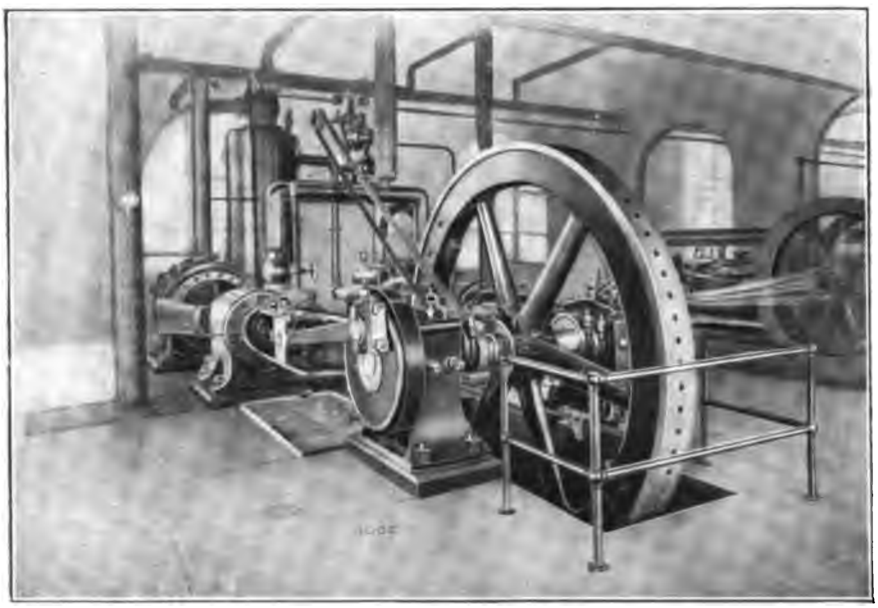
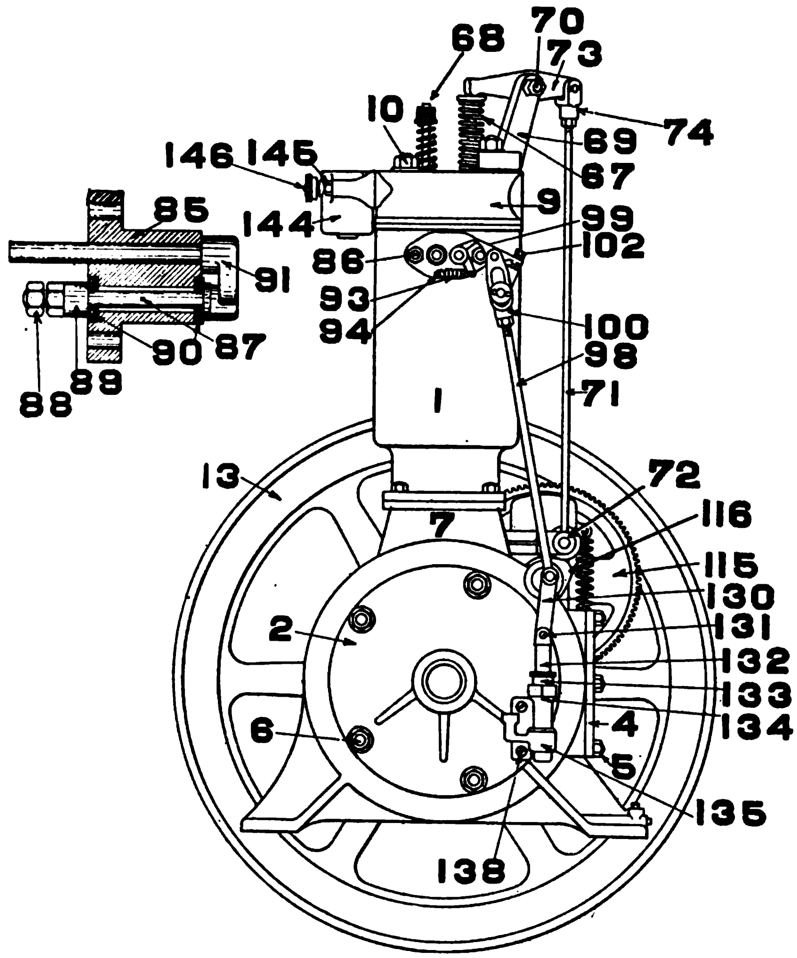


Fig. 2534. Ingersoll-Sergeant Air Compressor. Terminal Railway Association of St. Louis.

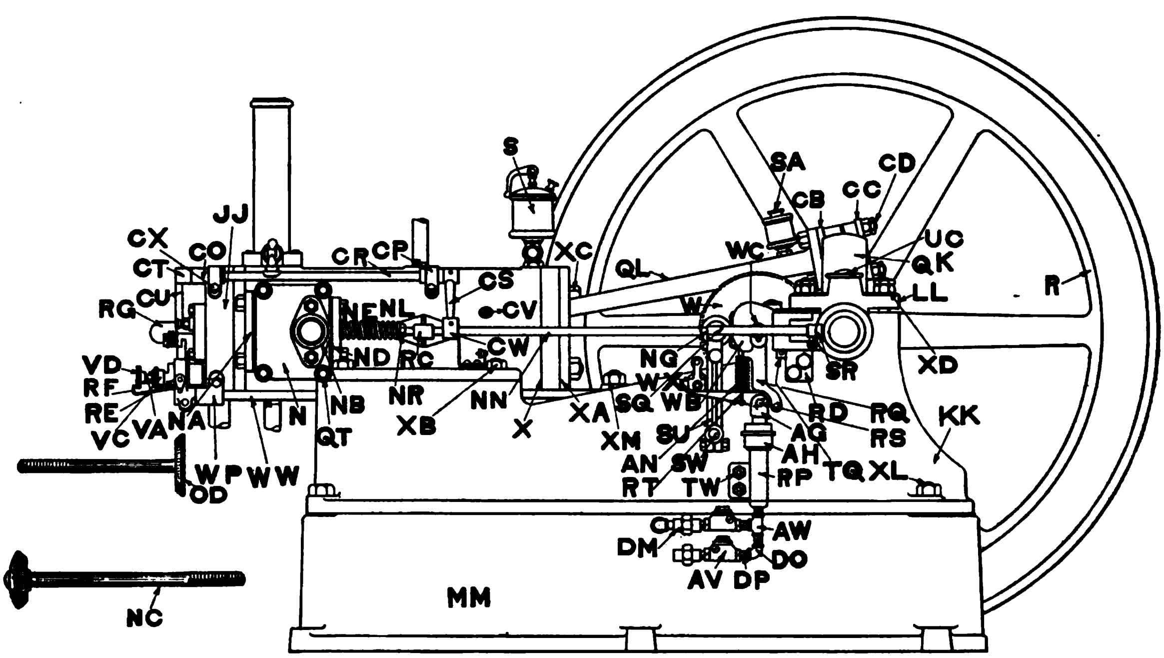
Figs. 2535-2538. "Kewanee" Brass and Malleable Iron Self-Seating Ball Joint Flange Union. National Tube Company.

Numbers Refer to List of Names of Parts on Following Page.

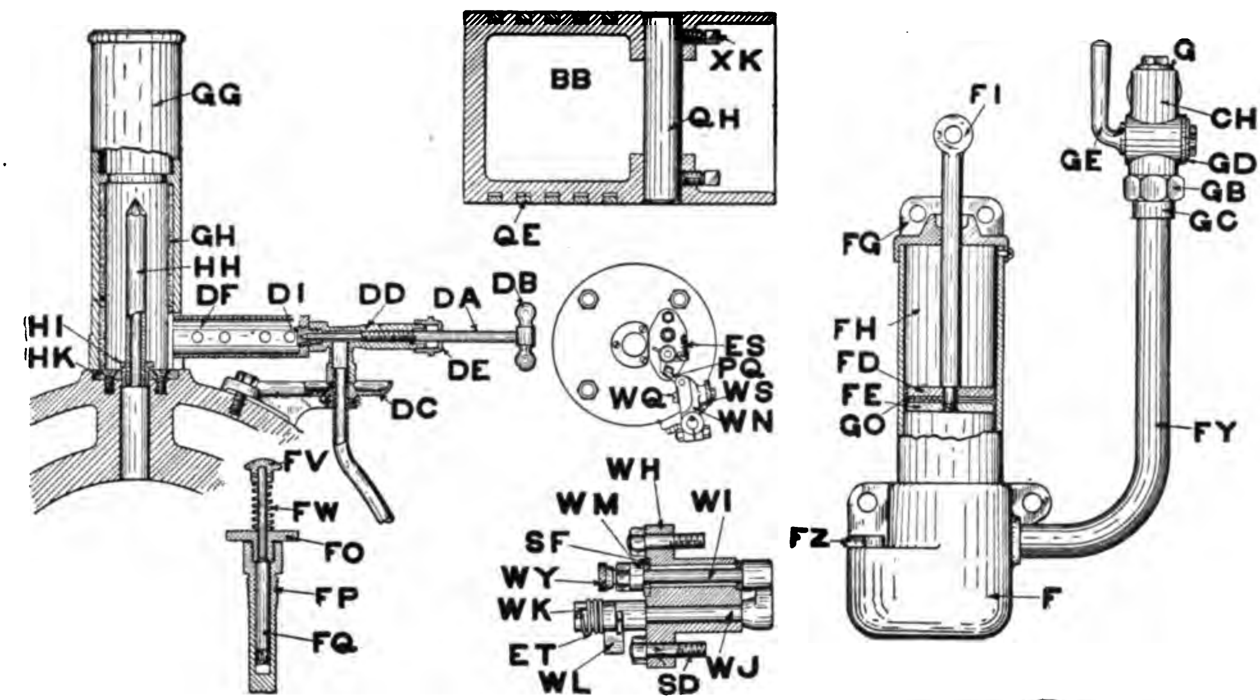


Figs. 2539-2540. Vertical Gasolene Engine. Fairbanks-Morse & Co.

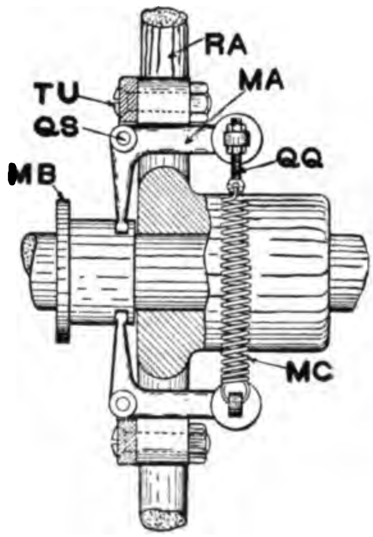
Letters Refer to List of Names of Parts on Following Page.



Figs. 2541-2544. Horizontal Gasolene Engine. Fairbanks-Morse & Co.



Figs. 2545-2552. Detail Parts of Horizontal Gasolene Engine. Fairbanks-Morse & Co.



Names of Parts, Fairbanks-Morse Vertical Gasolene Engine; Figs. 2539-2540.

1 *Cylinder*
2 *Bearing Plate*
4 *Hand Hole Plate*
5 *Stud*
6 *Bearing Plate Stud*
7 *Base*
9 *Cylinder Head*
13 *Fly Wheel*
67 *Exhaust Valve and Spring*
68 *Admission Valve and Spring*
69 *Exhaust Rocker Bracket*
70 *Exhaust Rocker Pin*
71 *Exhaust Rod and Nut*
72 *Exhaust Cam Roller*
73 *Exhaust Rocker Roller*
85 *Igniter Body*
86 *Ignition Studs*
87 *Fixed Electrode*
88 *Fixed Electrode Thumb Nuts*
89 *Igniter Collar*
90 *Mica Washers*
91 *Movable Electrode*
93 *Catch Spring*
94 *Eye Screw*
96 *Spiral Spring*
98 *Igniter Rod and Nut*
99 *Igniter Pawl*
100 *Igniter Pawl Block*
102 *Igniter Pawl Spring Stud*
115 *Large Gear with Shaft*
116 *Exhaust Cam*
130 *Pump Link*
131 *Pump Link Pin*
132 *Pump Plunger*
133 *Pump Gland*
134 *Pump Body*
135 *Pump Valve Chamber*
138 *Pump Cap Screw*
144 *Reservoir on Cylinder*
145 *Reservoir Cap Screw*
146 *Throttle Valve Hand Wheel*

Names of Parts, Fairbanks-Morse Horizontal Gasolene Engine; Figs. 2541-2552.

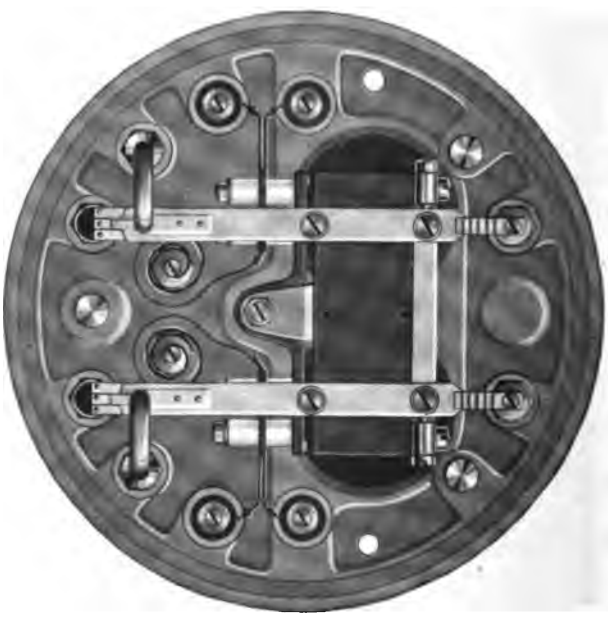
AG *Gasolene Pump Plunger*
AH *Gasolene Pump Packing Nut*
AV *Swing Checks. Pump Connections*
AW *"T," Gasolene Pump Connections*
BB *Piston*
CB *Connecting Rod Crank Brass, Back*
CC *Connecting Rod Crank Brass, Cap*
CD *Connecting Rod Crank Brass, Bolts and Nuts*
CH *Combination Cock Body*
CO *Bearing Bracket for* **CR**
CP *Bearing Bracket for* **CR**
CR *Shaft of Valve Lock*
CS *Arm Operating Valve Lock*
CT *Collar Hub for* **CU**
CU *Spring Blade for Suction Valve Lock*
CV *Roller on* **CS**
CW *Slotted Cam on Exhaust Rod*
DA *Needle Valve Stem to Bunsen Burner*
DB *Needle Valve Handle*
DC *Burner Bracket and Oil Cup*
DD *Bunsen Burner Body*
DE *Bunsen Burner Packing Nut*
DF *Perforated Air Sleeve*
DI *Burner Nozzle*
ES *Spiral Spring*
ET *Spring Around Movable Electrode*
F *Starter Pump Base*
FD *Starter Pump Piston, Top Section*
FE *Starter Pump Piston, Bottom Section*
FG *Starter Pump Cap*
FH *Barrel of Starter Pump*
FI *Starter Pump Piston Rod*
FO *Screw Cap Plunger Guide*
FP *Tube Screwed Into Cylinder*
FQ *Detonator Plunger*
FV *Plunger Cap*
FW *Plunger Spring*
FY *Curved Pipe From Starter Pump*
FZ *Cap Over Filling Hole in Pump Base*
GB *Hexagon Nut*
GC *Half Union Connection*
GP *Washer and Nut for Starter Pump Lever Cock*
GG *Chimney*
GH *Asbestos Chimney Lining*
GO *Leather Packing for Starter Pump*
HH *Igniter Tube*
HI *Brass Bushing for* **HH**
HK *Igniter Tube Plate in Cylinder*
JJ *Cylinder Head*
KK *Upper Engine Base*
LL *Pillow Block Caps*

(Continued on following page.)

MA *Governor Weight Arm*
MB *Governor Sleeve on Engine Shaft*
MC *Governor Tension Spring*
MM *Lower Engine Base*
N *Exhaust Valve Case*
NA *Exhaust Cap*
NB *Exhaust Valve Pipe Flanges*
NC *Exhaust Valve*
ND *Exhaust Valve Guide Ends*
NE *Exhaust Valve Spring*
NG *Exhaust Rod Roller*
NL *Exhaust Valve Spring Cover*
NN *Exhaust Rod*
NR *Nut*
OD *Admission Valve*
PQ *Igniter Pawl*
QE *Piston Rings*
QH *Connecting Rod Pin in Piston*
QK *Crank in Engine Shaft*
QL *Connecting Rod*
QQ *Governor Tension Spring Eye-Bolts*
QS *Pin in Governor Bracket for Weight*
QT *Studs and Nuts for Bolting Exhaust Valve Shell to Cylinder*
R *Fly Wheel*
RA *Governor Fly Wheel*
RC *Exhaust Rod Guide Bracket*
RD *Detent Catch Bracket*
RE *Gasolene Reservoir*
RF *Throttle Valve Dial Index Pointer*
RG *Suction Valve Cap*
RP *Gasolene Pump Body*
S *Oil Cup*
SA *Connecting Rod Oiler*
SD *Igniter Stud*
SF *Mica Insulating Washer*
SQ *Governor Detent Catch*
SR *Detent Catch Roller*
SU *Exhaust Rod Rocker Arm*
SW *Rocker Arm Pin*
TQ *Taper Pin in Bracket*
TU *C. S. H. Bolts*
TW *Gasolene Pump Cap Screw*
UC *Bearing Oiler Cap*
VA *Throttle Valve Stem*
VC *Gasolene Reservoir Packing Nut*
VD *Throttle Valve Dial*
W *Large Gear*
WB *Cam on Large Gear*
WC *Cam Shaft on Large Gear*
WN *Rocker Arm*
WP *Bracket Bearing*
WQ *Pawl Adjusting Bolt*
WS *Adjusting Thumb Nut*
WW *Igniter Rocking Shaft*
WX *Bracket*
X *Engine Cylinder*
XA *Engine Cylinder Ring*
XB *Stud*
XC *Stud*
XD *Stud*
XK *Set Screws in Piston*
KL *Stud*
XM *Bolt*

Elevation.

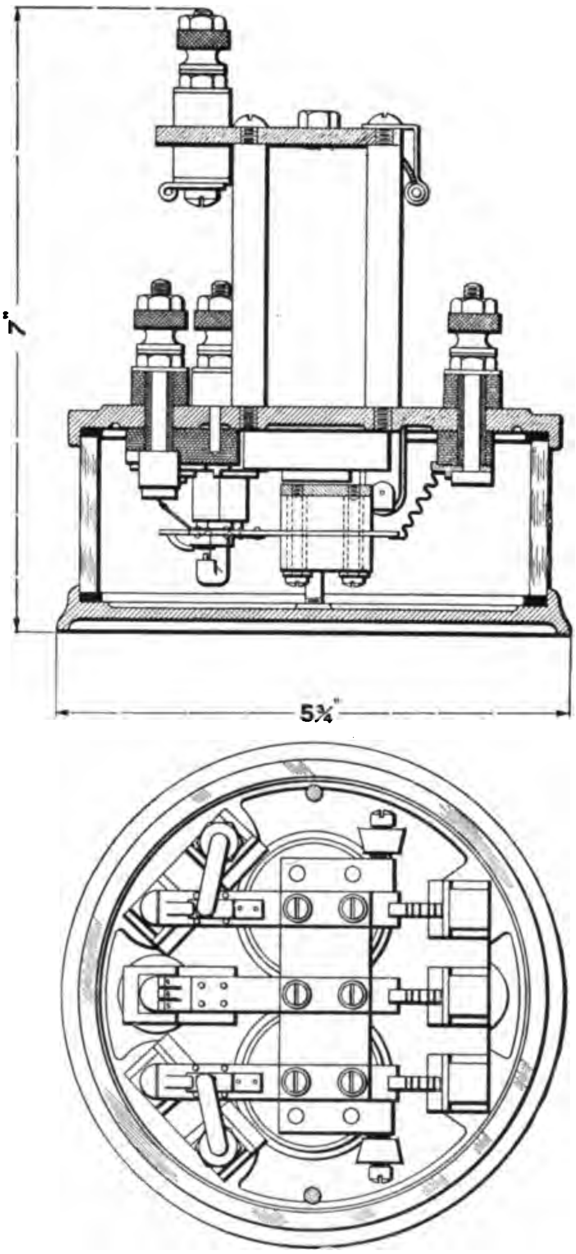
Inverted View, Showing Arrangement of Polarized Armature and Polar Contacts.



Inverted View, Showing Arrangement of Neutral Armature and Contacts.

Figs. 2553-2555. Model 1 Relay, Polarized Type. The Union Switch & Signal Company.

Figs. 2556-2557. Plan and Sectional Views of Model 1 Relay, Neutral Type. The Union Switch & Signal Company.

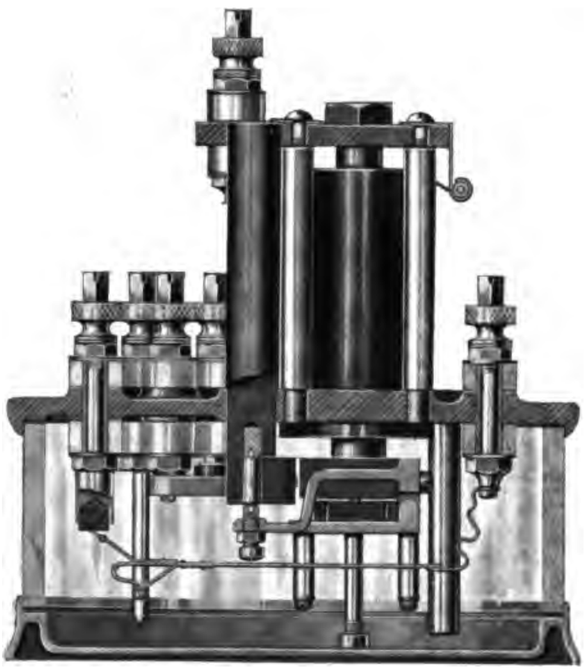


Figs. 2558-2559. Model 1-C Relay. The Union Switch & Signal Company.

THE "UNIVERSAL" RELAY

THE UNION SWITCH & SIGNAL COMPANY

The polarized relay, made by the Union Switch & Signal Company, Figs. 2553-2555, consists of an ordinary relay with the addition of a polarized armature and permanent magnet. The permanent magnet can be seen in the elevation, Fig. 2553, centrally placed a little in front of the regular relay coils. Below this permanent magnet is suspended the polarized armature, which swings on its center. Its extremities are near the pole pieces of the neutral magnet, as can be seen from the inverted view. The arrangement is such that both ends of the polarized armature have the same sign which, when the neutral magnet is de-energized, is opposite to that of the neutral pole pieces, which both have like signs also. Consequently, when the neutral magnet is de-energized, the polarized armature tends to assume a neutral position, but as soon as current flows in the coils of the neutral magnet, its poles become of opposite polarity, and one attracts the adjacent end of the polarized armature while the other pole repels its adjacent end. This causes the polarized armature to swing through a small arc and make appropriate contacts. When the current in the neutral magnet is reversed, the pole that attracted its adjacent end of the polarized armature will repel it and vice versa.



Figs. 2560-2561. Sectional View of Model 2 Relay, Neutral Type. The Union Switch & Signal Company.

Fig. 2562. Model 2 Relay, Neutral Type; Inverted View, Showing Arrangement of Armature and Contacts. The Union Switch & Signal Company.

HEAVY CURRENT RELAY

GENERAL RAILWAY SIGNAL COMPANY

At electric interlocking plants and other places where heavy currents must be broken, special relays must be provided in order that the points shall not be burned off by an arc. Such a relay, made by the General Railway Signal Company, is shown in Fig. 2568, and a wiring diagram illustrating its operation in Fig. 2565a. It consists of vertical magnet coils mounted on a slate base with the armature and contact arms on top. The armature opens by gravity through a counterweight. The upright fixed contact consists of an iron core on which a heavy carbon contact block is fastened. About the core is wound a low resistance coil forming part of the circuit between the contact block and binding post. If an arc should form when the contact opens the magnetic flux from the coil would extinguish it.

NEUTRAL RELAY

GENERAL RAILWAY SIGNAL COMPANY

Figs. 2566-2567 show the neutral relay, Model 9, made by the General Railway Signal Co. This relay is provided with four platinum to graphite front contacts and four platinum to platinum back contacts. The top and bottom frames are of brass, and the working portion of the relay is enclosed and sealed in a glass case. All parts are highly insulated and subjected to a breakdown test of 3,500 volts.

The magnetic circuit is short, and the cores are rigidly fastened to the brass top. The coils are form wound and taped after which they are treated by the vacuum process, which deposits a layer of insulating material around each individual wire, and in addition provides protection from mechanical injury to the outside of the coil. These coils are removable without opening the relay, by taking off the yoke from the top and the hard rubber shells, after which the coils can be slipped off.

Ample room is allowed for extra large coils, thus providing for a low pick-up point. These relays are adjusted to drop away at one-half of the pick-up. Binding posts are readily accessible and strongly constructed. The over-all dimensions of the relay are approximately 6" x 7" x 8½".

Figs. 2563-2564. Model 9 Neutral Relay. The Union Switch & Signal Company.

Fig. 2565. Heavy Current Relay. General Railway Signal Company.

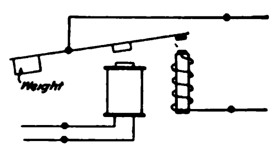


Fig. 2565a. Circuit Diagram for Fig. 2565.

POLARIZED RELAY

GENERAL RAILWAY SIGNAL COMPANY

The Model 9 polarized relay is shown in Figs. 2568 and 2569. It is of the same size and construction as the neutral relay except for the addition of a permanent magnet and polarized armature with the necessary contacts. The polarized armature, one end of which swings between the neutral pole pieces, is suspended below the permanent magnet. The principles involved in its operation are the same as in the case of the Union Universal relay, Figs. 2553-2555.

Fig. 2566. Model 9 Neutral Relay, Front View. General Railway Signal Company.

Fig. 2567. Model 9 Neutral Relay, Rear View. General Railway Signal Company.

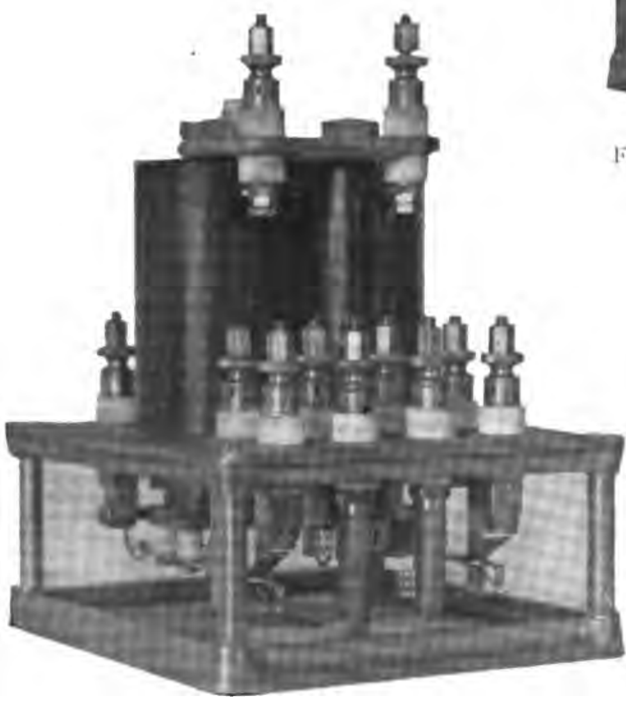


Fig. 2568. Model 9 Polarized Relay. General Railway Signal Company.

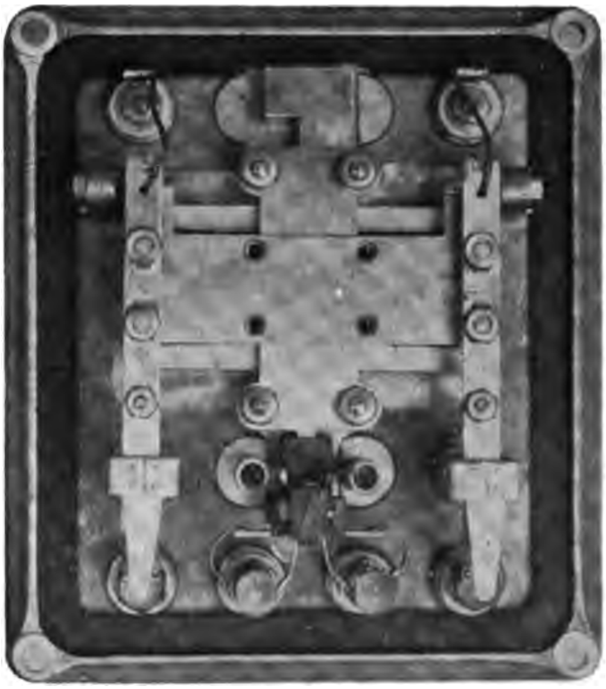
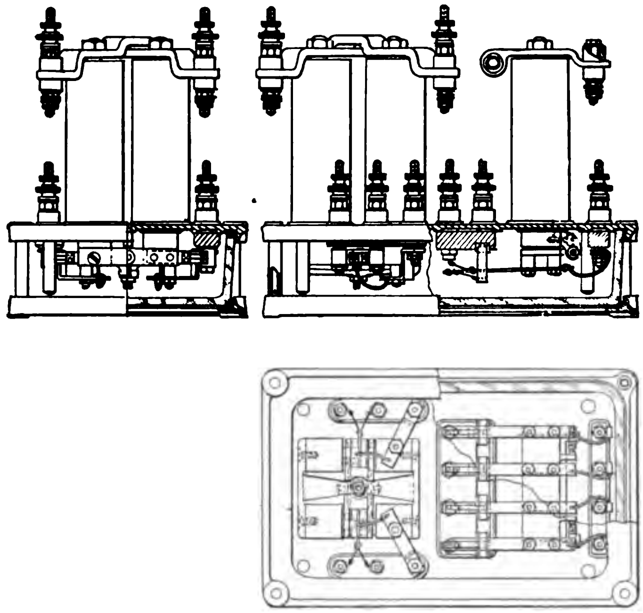


Fig. 2569. Model 9 Polarized Relay, Inverted View, Showing Neutral and Polarized Armatures. General Railway Signal Company.

POLARIZED RELAY
HALL SIGNAL COMPANY

The "Neutral Polar Relay," made by the Hall Signal Company (Figs. 2574-2575) consists of a neutral and a polarized armature with contacts on each, whose magnets and binding posts are mounted on a porcelain base. The polarized armature B consists of a permanent magnet, carrying contact fingers at one end and is pivoted in the center between the magnets. The front end operates between the two magnet core pole pieces C, which are extended to the sides of the magnets, and the back end carries the contacts F. On account of the arrangement of the polarized armature between the pole pieces and back strap, by which a maximum number of the lines of force are utilized in moving it, the polarized armature operates on a very small amount of energy. The moving parts of the instrument are protected by a glass cover, clamped in place, with provision made for sealing. The neutral armature A carries four-contact fingers, E back and D front, and the polarized armature can carry two fingers by which two separate contacts are provided. Connection between the contact fingers, magnets, etc., and the binding posts is made by wires passing through the porcelain base and running in grooves in the bottom. All holes for the wires are sealed with wax.

Fig. 2570. Neutral Relay. General Electric Company.



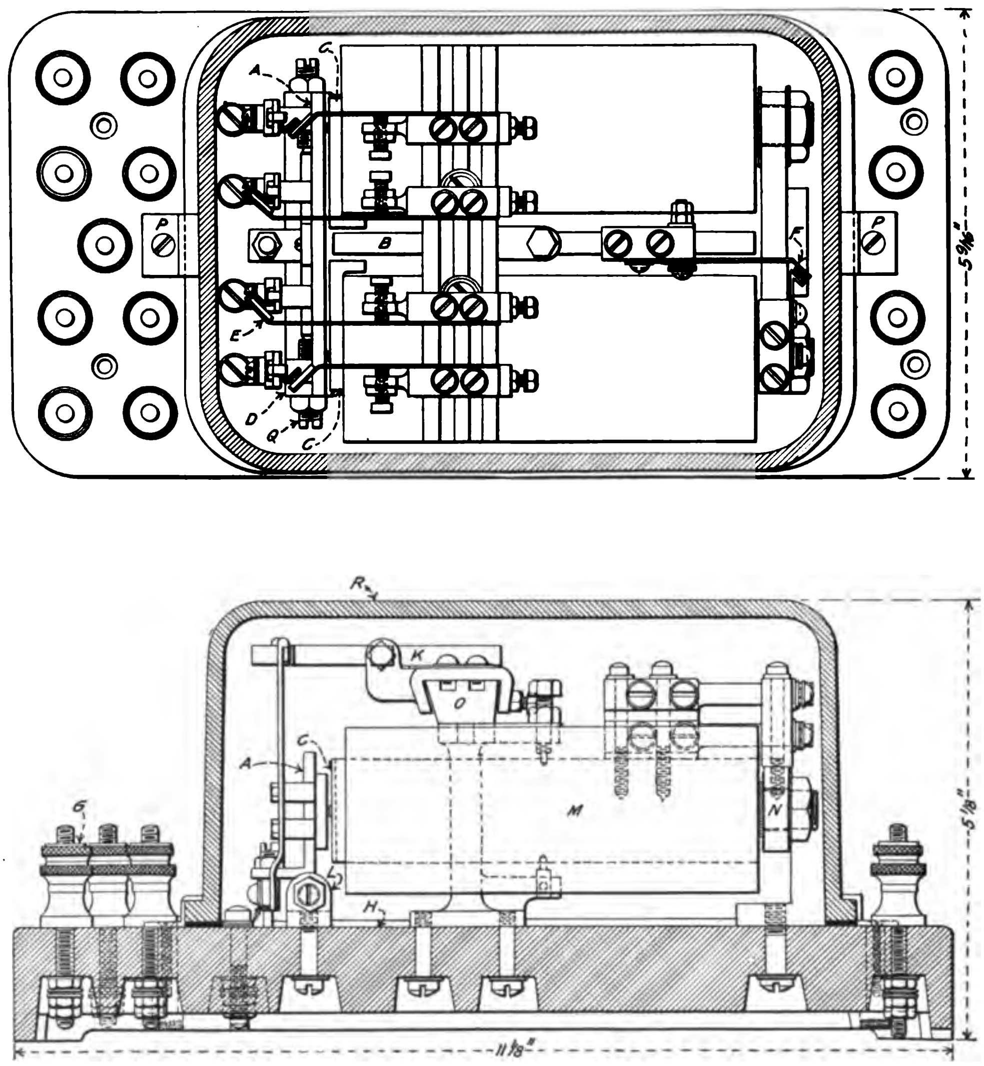
Figs. 2571-2573. Differential Relay. Hall Signal Company. See Fig. 380.

THE HALL DIFFERENTIAL RELAY.

This relay (Figs. 2571-2573) is used in connection with the Hall wireless system of control for home and distant automatic signals, Fig. 380.

The two coils at the right of the figure are regular neutral coils of a track relay, wound to 4 ohms. The four coils at the left are the coils of the differential relay arranged so that the back straps connect coils diametrically opposite. One set of these coils connected by one back strap is wound to a resistance of ⅛ ohm, the other set is wound to a higher resistance, for example, 6 ohms.

The track relay coils are provided with an armature as in the General Railway Signal Company's Model 9 relay (Figs. 2566-2569). The differential armature is pivoted in the middle and swings between the pole pieces of the differential coils. The magnet cores and binding posts are mounted on a brass frame which rests on a glass dish, which, in turn rests in a second brass frame. The two frames are held together by brass screws. The binding posts are supported in such manner that they cannot turn, and the coils are form-wound. The lower part of the relay is watertight and can be sealed.



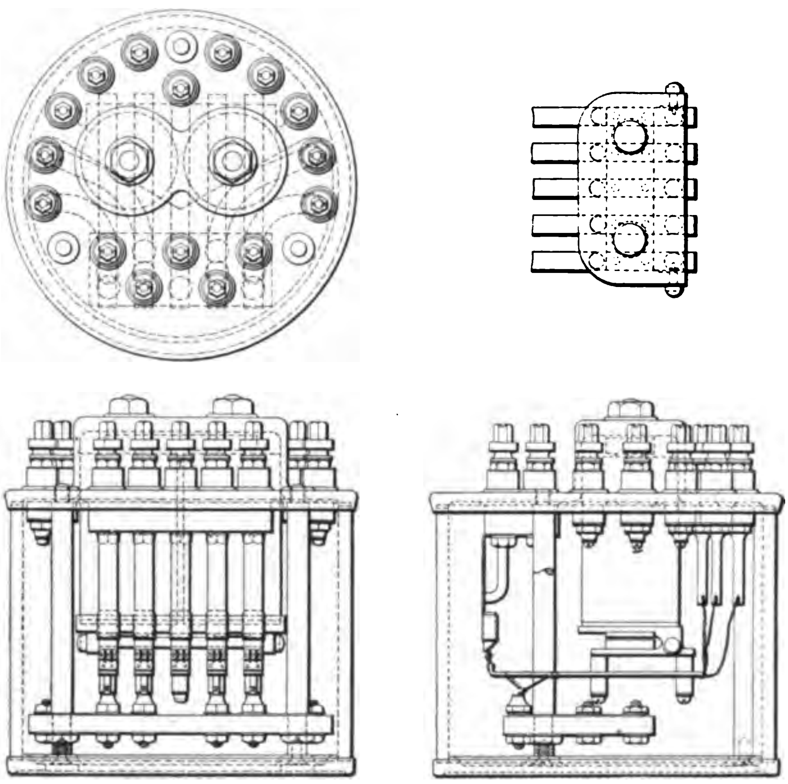
Figs. 2574-2575. Glass Enclosed Porcelain Base Polarized Relay. Hall Signal Company.

Names of Parts, Hall Polarized Relay; Figs. 2574-2575.

A *Neutral Armature*	**E** *Back Contact*	**K** *Contact Spring*	**O** *Insulating Contact Support*
B *Polar Armature*	**F** *Polar Contact*	**L** *Trunnion Support*	**P** *Clamp for Glass Shield*
C *Neutral Pole Piece*	**G** *Binding Post*	**M** *Magnet*	**Q** *Trunnion Screw*
D *Front Contact*	**H** *Porcelain Base*	**N** *Back Strap or Yoke*	**R** *Glass Shield*

Fig. 2576. Glass Enclosed, Porcelain Base Neutral Relay. Hall Signal Company.

Fig. 2577. Neutral Enclosed Relay. American Railway Signal Company.



Figs. 2578-2581. Neutral Enclosed Relay. American Railway Signal Company. See Fig. 2577.

Names of Parts, Neutral Relay; Fig. 2583.

1 *Base*
2 *Magnet*
3 *Magnet Support*
4 *Front Contact Finger*
5 *Armature*
6 *Armature Support*
7 *Adjusting Screw Jam Nut*
8 *Adjusting Screw*
9 *Contact Finger Support*
10 *Flexible Connection*
11 *Back Strap or Yoke*
12 *Tension Spring*
13 *Contact Spring*
14 *Trunnion Support*
15 *Back Contact Finger*
16 *Contact Finger Pedestal*
17 *Tension Spring Adjusting Screw*
18 *Pedestal for* **17**
19 *Name Plate*
20 *Binding Post*

Names of Parts, Neutral Relay; Fig. 2584.

1 *Armature*
2 *Armature Lever*
3 *Contact Spring Support*
4 *Contact Spring*
5 *Counterweight*
6 *Binding Post*
7 *Contact Block*
8 *Magnet*
9 *Base*
10 *Flexible Connection*
11 *Trunnion Support*
12 *Screw*

Fig. 2582. Mercury Contact Relay. McClintock Manufacturing Company.

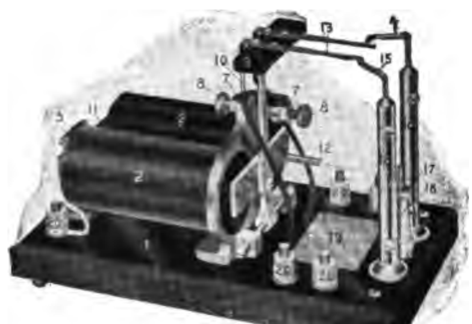


Fig. 2583. Neutral Relay. Railroad Supply Company.

THE MERCURY CONTACT RELAY

McCLINTOCK MANUFACTURING COMPANY

Fig. 2582 is a view of the relay made by the McClintock Manufacturing Company. No contact fingers are used, but circuits are controlled by mercury in hollow glass rings from which the air has been exhausted. Platinum points, sealed into the glass, project within the tubes and with these the mercury makes contact when the ring is revolved to a certain position. Motion is transmitted to the glass rings from the armature by a system of levers acting on a shaft on which clamps are mounted to hold the rings. The shaft turns in trunnion bearings. Flexible spirals of insulated wire connect the platinum contact points to the binding posts mounted on a marble top. The whole relay is glass enclosed.

Fig. 2584. Neutral Relay. Railroad Supply Company.

Fig. 2585. Enclosed Slate Base Relay. Railroad Supply Company.

Fig. 2586. Inverted View of Relay Shown in Fig. 2588.

Fig. 2587. Sectional View of Relay Shown in Fig. 2588.

Fig. 2588. Enclosed Neutral Relay. Railroad Supply Company.

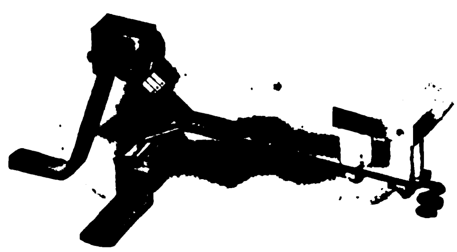
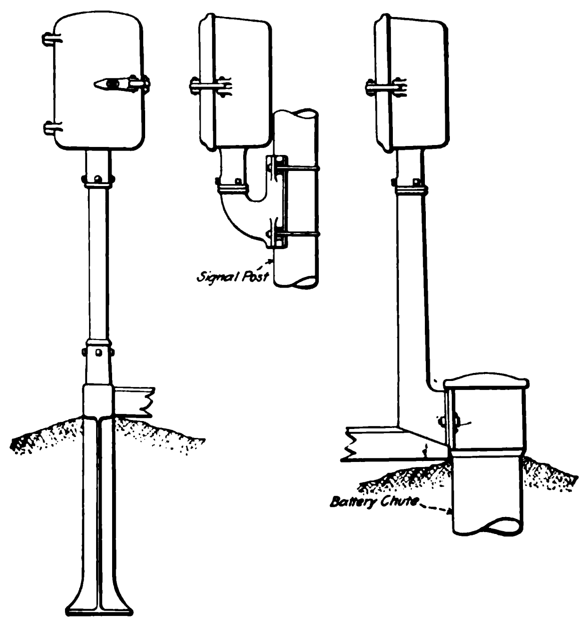


Fig. 2589. Detail of Contacts of Relay Shown in Fig. 2585.


Fig. 2590. Iron Relay Box with Two Universal Relays and Lightning Arresters in Place. The Union Switch & Signal Company.

Fig. 2591. Iron Relay Box for Crossing Bell Post. The Union Switch & Signal Company.

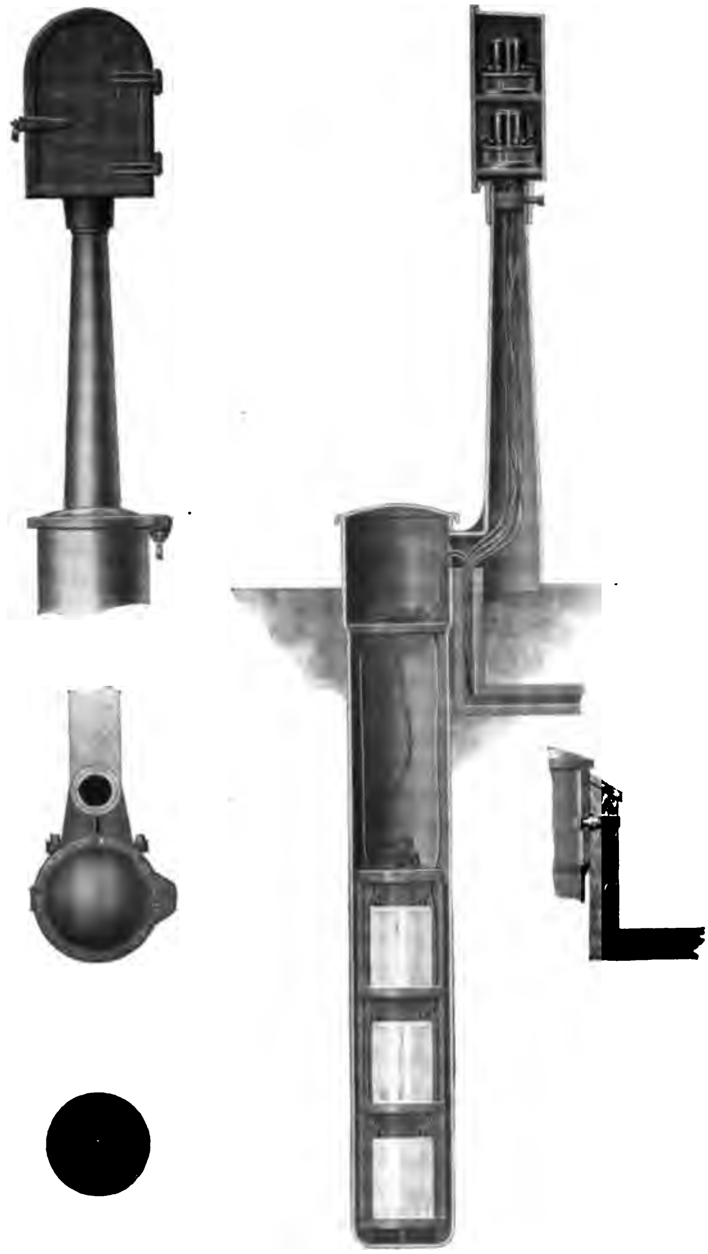
Fig. 2592. Wooden Relay Box with Frost Door. Bryant Zinc Company.



Figs. 2593-2594. Iron Relay Boxes and Posts. The Union Switch & Signal Company.

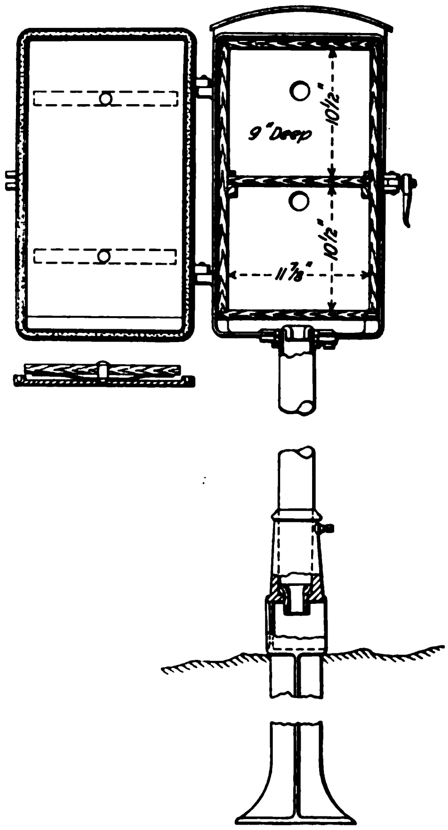
Figs. 2595-2596. Cast Iron Instrument Case. The Union Switch & Signal Company.

Figs. 2597-2598. Two Interlocking Relays in Case. Railroad Supply Company.

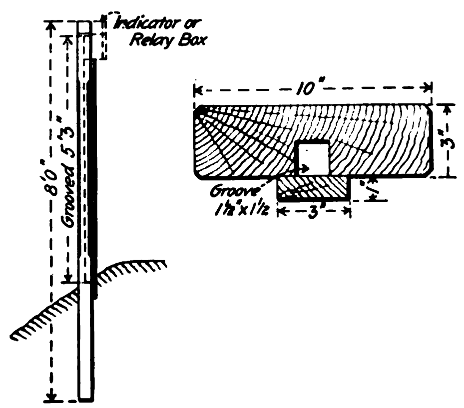


Figs. 2599-2600. Single Cast Iron Battery Chute with Cast Iron Post and Relay Box. The Union Switch & Signal Company.

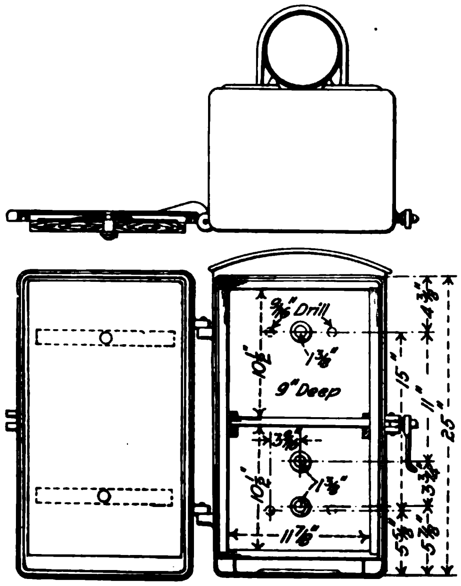
Fig. 2601. Relay Box and Battery Chute. Great Northern.



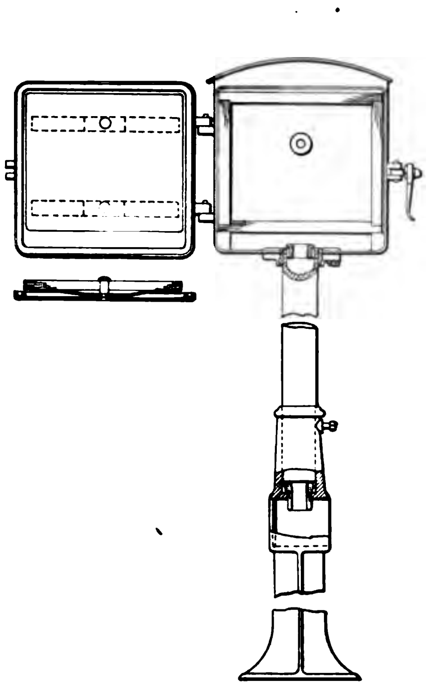
Figs. 2604-2605. Double Iron Relay Box on Iron Pipe Post. General Railway Signal Company.



Figs. 2602-2603. Relay Box or Indicator Post. Chicago & North-Western.



Figs. 2606-2607. Double Iron Relay Box. General Railway Signal Company.



Figs. 2608-2609. Single Iron Relay Box Mounted on Iron Pipe Post, with Cast Iron Base. General Railway Signal Company.

Fig. 2610. Relay Box for Interlocking Relay, Figs. 574-575. Railroad Supply Company.

Fig. 2611. Relays in Iron Relay Box. Bryant Zinc Company.

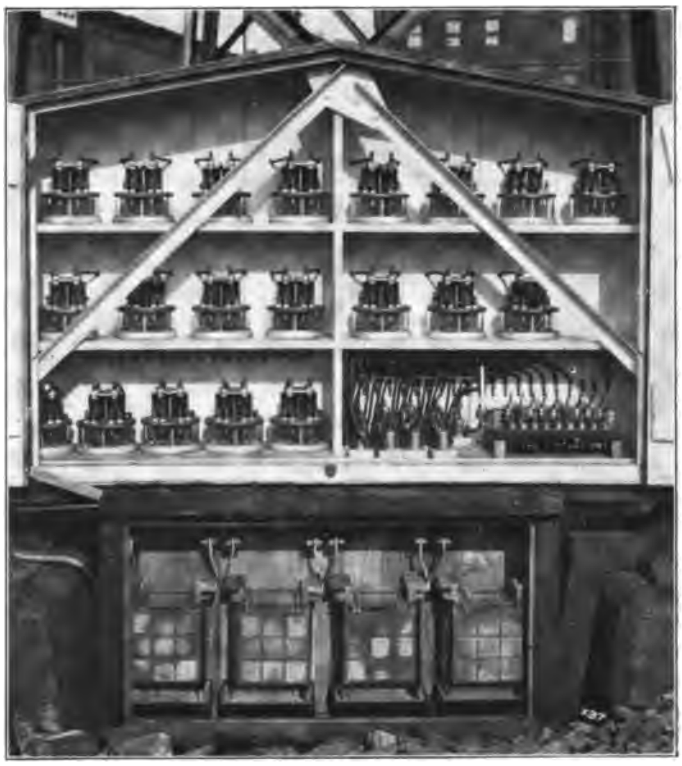
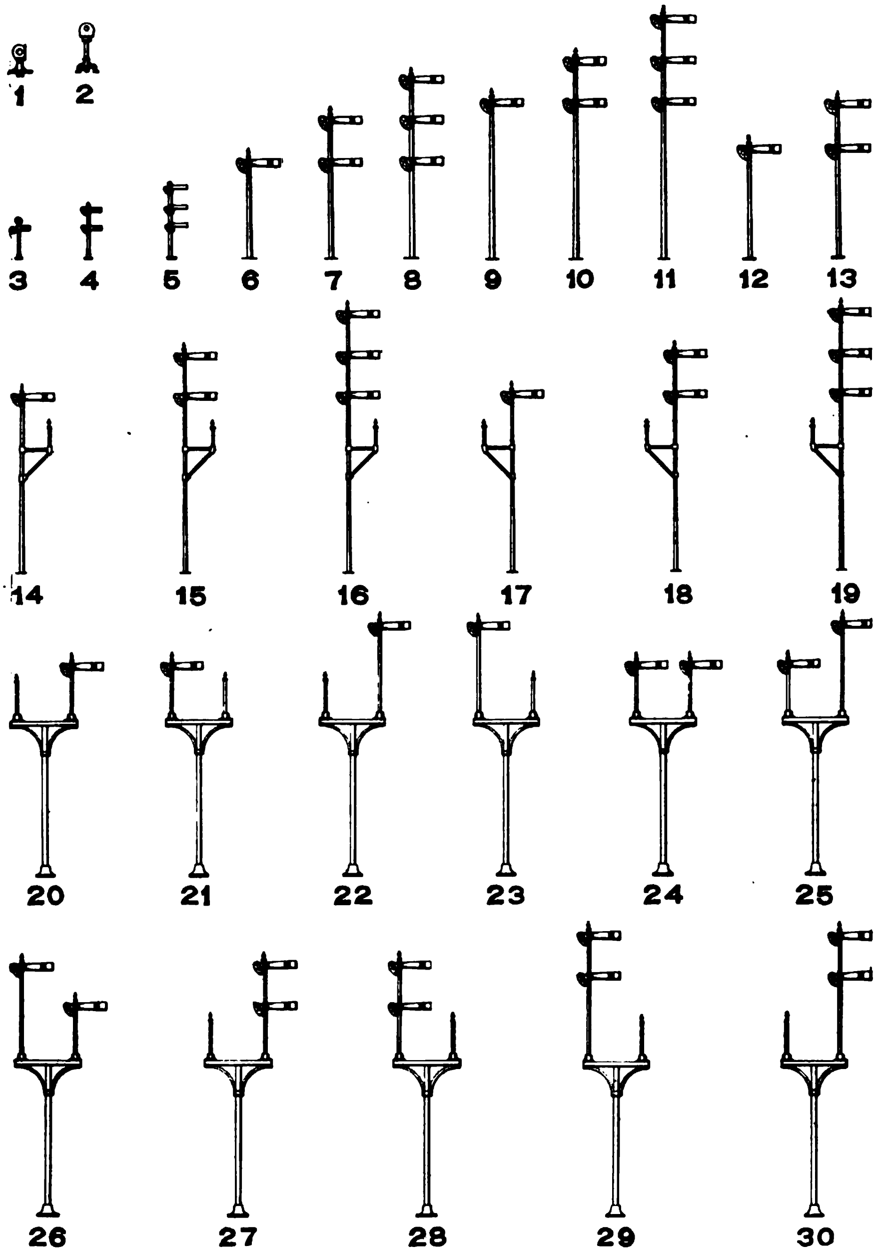


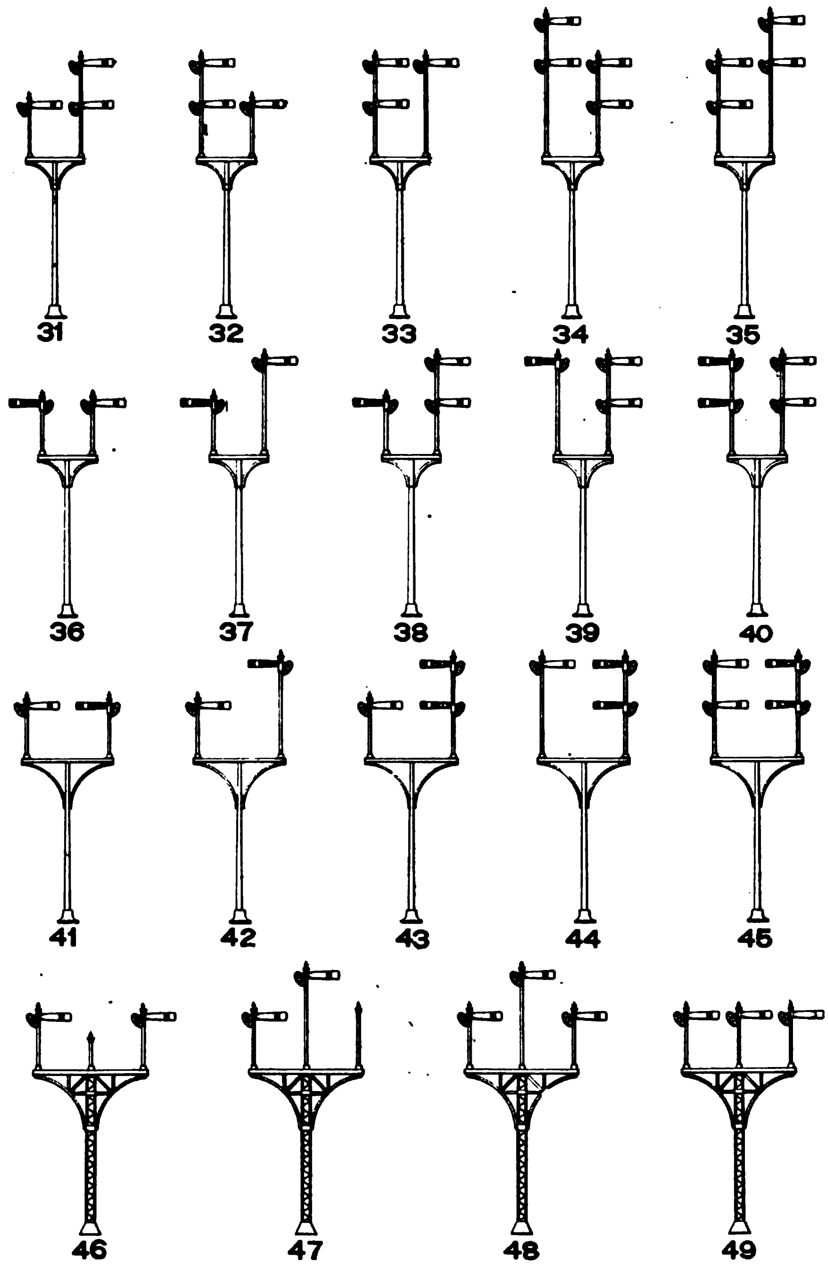
Fig. 2612. Relays, Resistances and Storage Cells in Box Set into Signal Bridge Leg. Delaware, Lackawanna & Western.



*Figs. 2613-2642. Typical Arrangements of Signals.

Names of Parts; Figs. 2613-2642.

1 *Low Pot Signal.*
2 *High Pot Signal*
3 *One-Arm Dwarf Signal*
4 *Two-Arm Dwarf Signal*
5 *Three-Arm Dwarf Signal*
6 *One-Arm Bridge Signal*
7 *Two-Arm Bridge Signal*
8 *Three-Arm Bridge Signal*
9 *One-Arm Ground Signal*
10 *Two-Arm Ground Signal*
11 *Three-Arm Ground Signal*
12 *One-Arm Elevated Railroad Signal*
13 *Two-Arm Elevated Railroad Signal*
14 *One-Arm Cantilever Signal*
15 *Two-Arm Cantilever Signal*
16 *Three-Arm Cantilever Signal*
17 *One-Arm Cantilever Signal*
18 *Two-Arm Cantilever Signal*
19 *Three-Arm Cantilever Signal*
20 *One-Arm Bracket Signal*
21 *One-Arm Bracket Signal*
22 *One-Arm Bracket Signal with High Doll*
23 *One-Arm Bracket Signal with High Doll*
24 *Two-Arm Bracket Signal*
25 *Two-Arm Bracket Signal, One High and One Low Doll*
26 *Two-Arm Bracket Signal, One High and One Low Doll*
27 *Two-Arm Bracket Signal*
28 *Two-Arm Bracket Signal*
29 *Two-Arm Bracket Signal, with High Doll*
30 *Two-Arm Bracket Signal, with High Doll*



*Figs. 2643-2661. Typical Arrangements of Signals.

Names of Parts; Figs. 2643-2661.

31 *Three-Arm Bracket Signal*
32 *Three-Arm Bracket Signal*
33 *Three-Arm Bracket Signal, with One High Doll*
34 *Four-Arm Bracket Signal, with One High Doll*
35 *Four-Arm Bracket Signal, with One High Doll*
36 *Two-Arm Bracket Signal*
37 *Two-Arm Bracket Signal, with One High Doll*
38 *Three-Arm Bracket Signal*
39 *Three-Arm Bracket Signal, with One High Doll*
40 *Four-Arm Bracket Signal*
41 *Two-Arm Bracket Signal*
42 *Two-Arm Bracket Signal, with One High Doll*
43 *Three-Arm Bracket Signal*
44 *Three-Arm Bracket Signal, with One High Doll*
45 *Four-Arm Bracket Signal*
46 *Two-Arm, Three-Doll, Lattice Post, Bracket Signal*
47 *Two-Arm, Three-Doll, Lattice Post, Bracket Signal*
48 *Three-Arm, Three-Doll, Lattice Post, Bracket Signal*
49 *Three-Arm, Three-Doll, Lattice Post, Bracket Signal*

Fig. 2662. Three-Position, Upper Quadrant, Normal Clear, Automatic Block Signals, with Top Post Mechanisms, on the Great Northern. General Railway Signal Company.

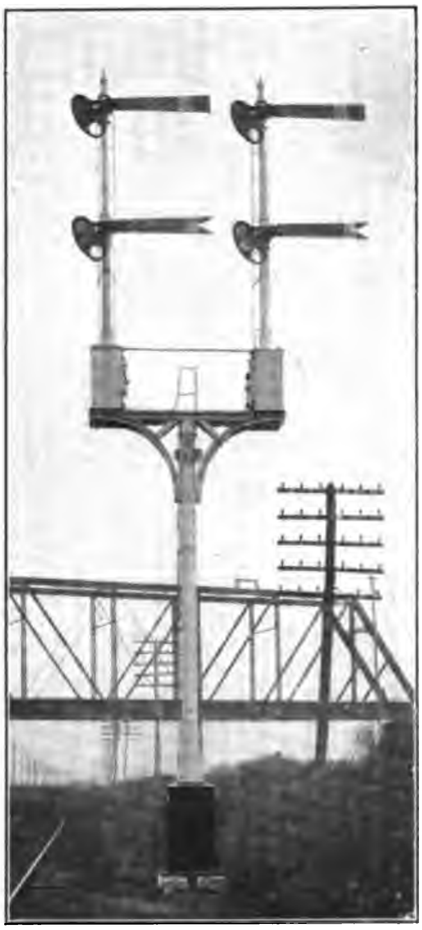


Fig. 2663. Two-Doll Bracket, Normal Danger, Automatic Block Signal. Central Railroad of New Jersey. Hall Signal Company.

Fig. 2664. Top Post Mechanism, Three-Position, Automatic Block Signal. Baltimore & Ohio. General Electric Company.

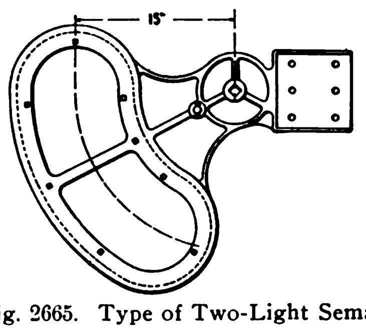


*Fig. 2665. Type of Two-Light Semaphore Casting.

Fig. 2666. Upper Quadrant, Electric Motor Signal. General Electric Company.

Fig. 2667. Hoboken Terminal Yard Showing Electro-Pneumatic Signals on Bridges. Delaware, Lackawanna & Western.

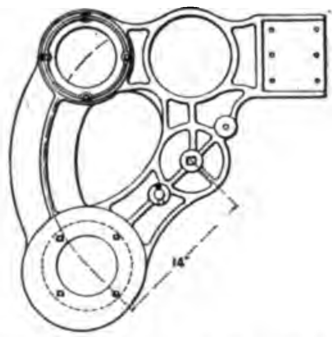
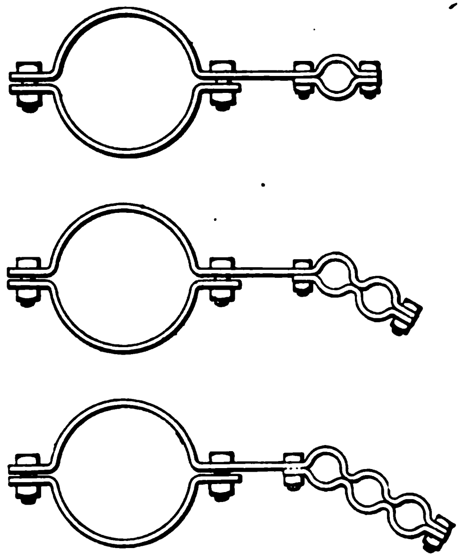


*Fig. 2668. Type of Two-Light Semaphore Casting.

Fig. 2669. Style B Motor Signal Operated by "Chloride Accumulator" on the Southern Pacific. The Union Switch & Signal Company.

Fig. 2670. Upper Quadrant, Electric Motor Signal. General Electric Company.

Fig. 2671. Electro-Pneumatic Interlocking Signals on Bridges. Delaware, Lackawanna & Western.



*Figs. 2672-2674. Pipe Guides for Iron Pipe Posts.

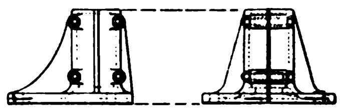
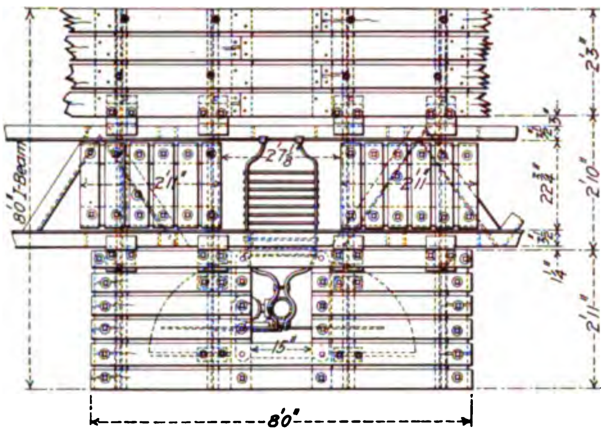
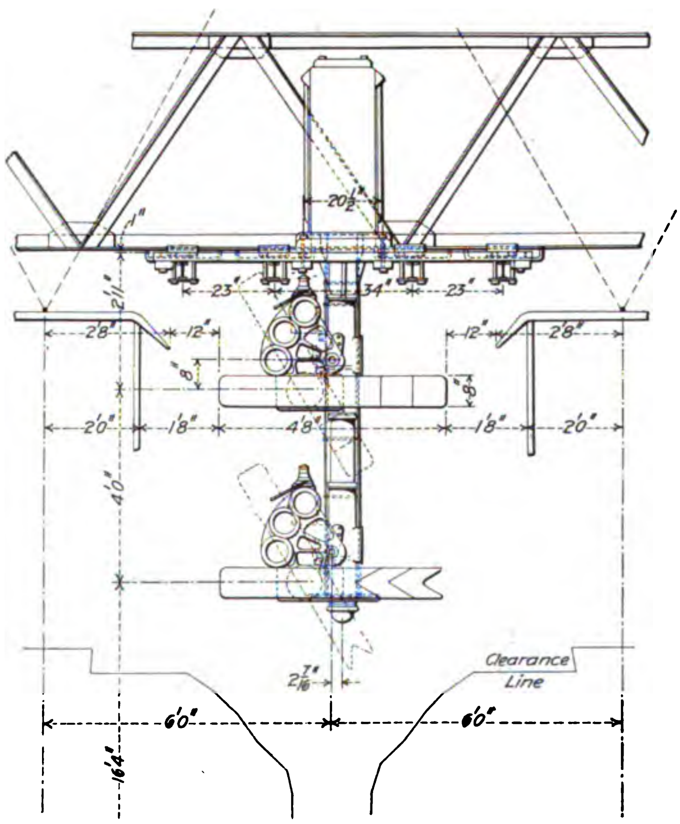
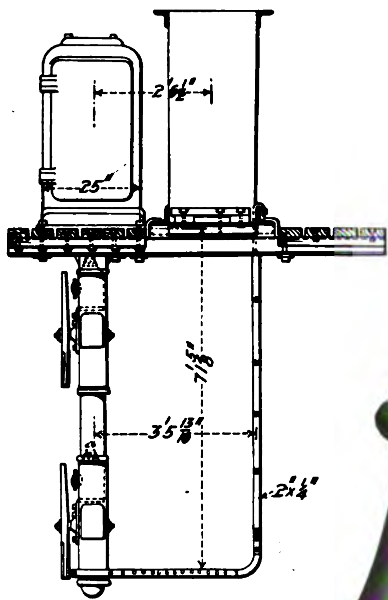


*Fig. 2675. Cast Iron Foundation for Iron Pipe Posts.



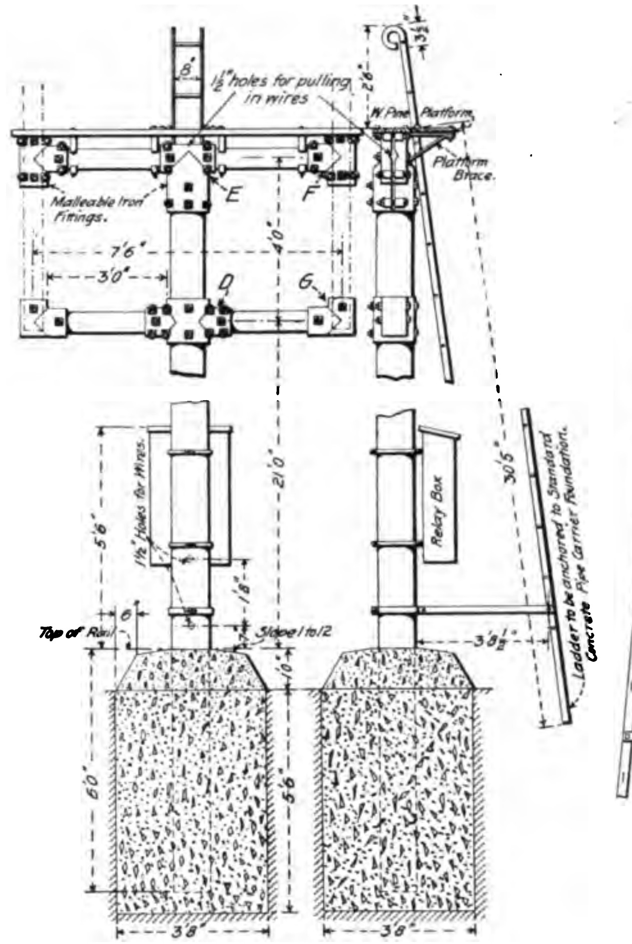
Plan.



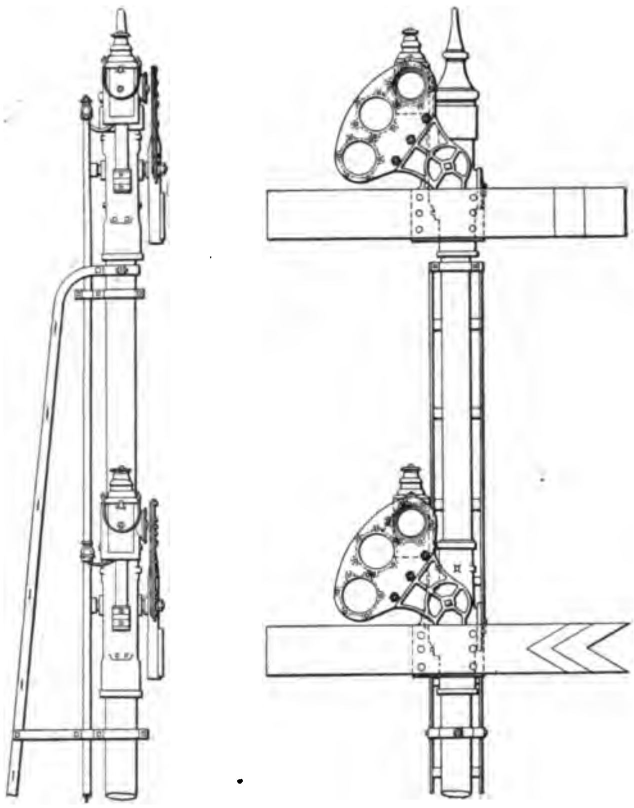


Figs. 2676-2678. Suspended Automatic Block Signal. New York, New Haven & Hartford.

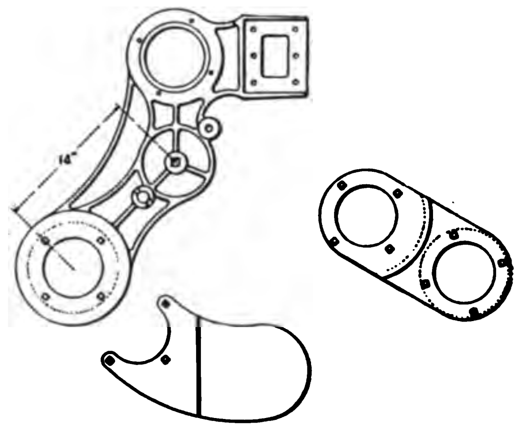
Fig. 2679. Signal Pinnacle. The Union Switch & Signal Company.



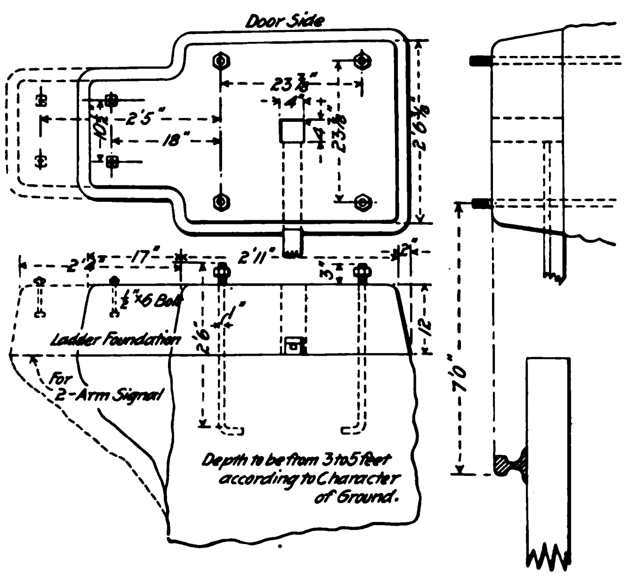
Figs. 2680-2681. Iron Pipe Bracket Post. Philadelphia & Reading.



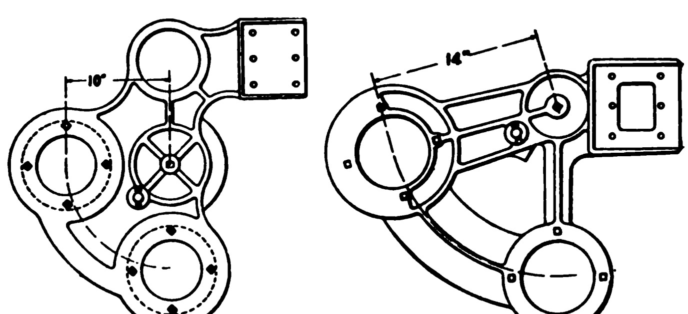
Figs. 2684-2685. Automatic Block Signal, Electrified Lines. New York, New Haven & Hartford.



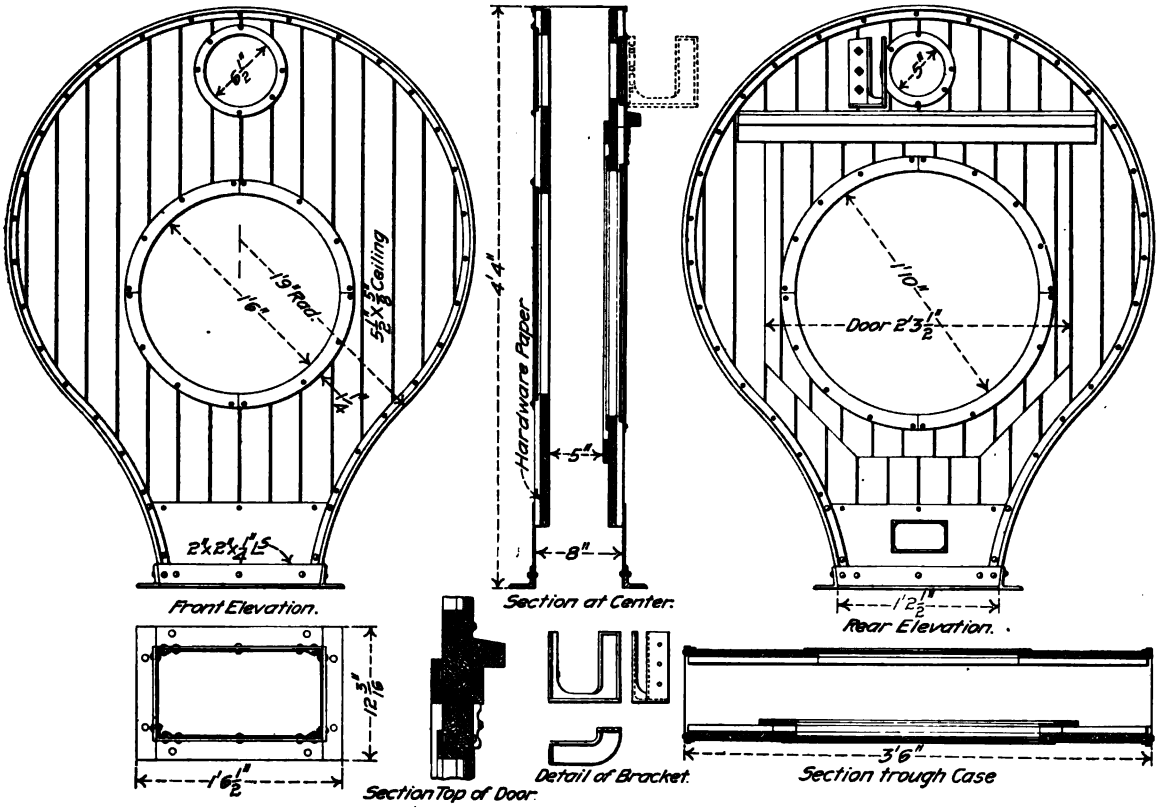
Method of Converting a Semaphore Casting from One to Two-Light.



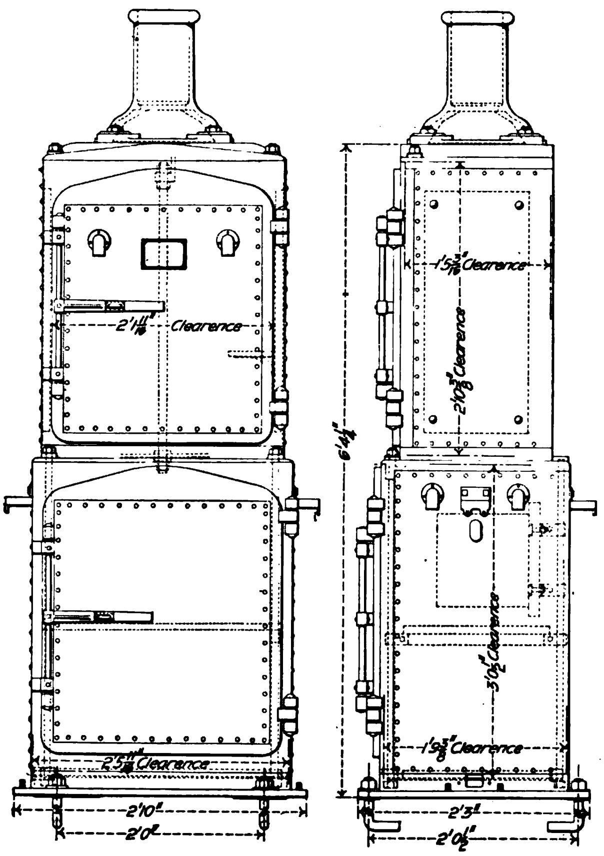
Figs. 2682-2683. Concrete Automatic Signal Foundation. Southern Pacific-Union Pacific.



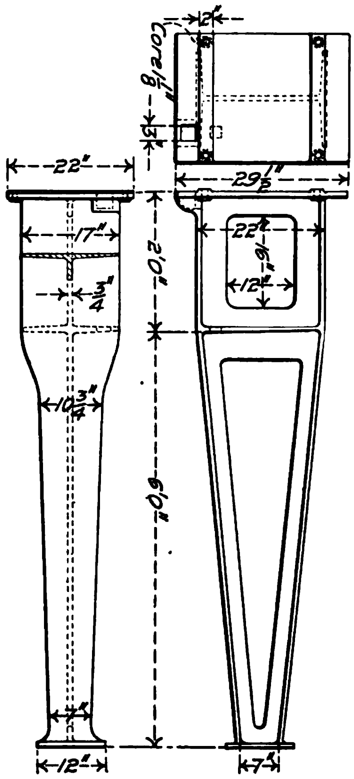
*Figs. 2686-2688. Types of Two-Light Semaphore Castings.



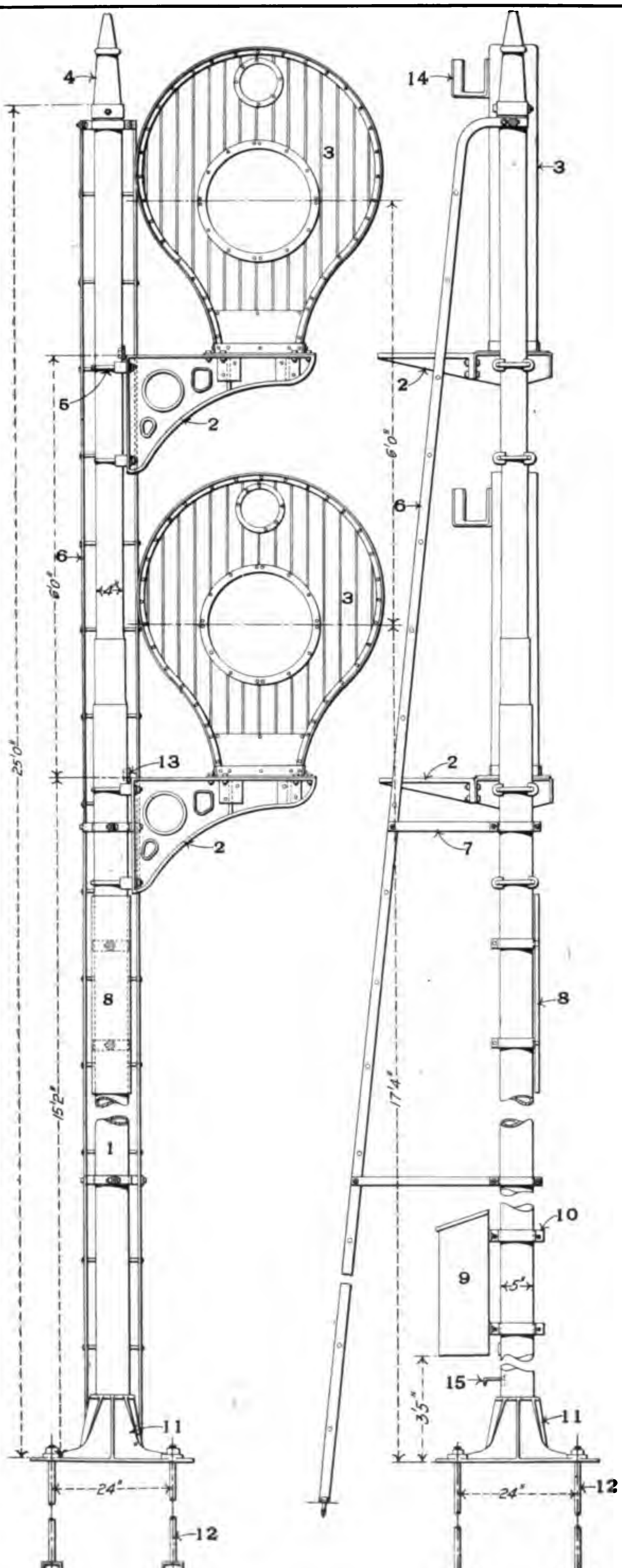
Figs. 2689-2697. Disk Signal Head and Details. See Figs. 403-407. Hall Signal Company.



Figs. 2698-2699. Mechanism and Battery Case for Electro-Gas or Electric Motor Signal. Hall Signal Company.



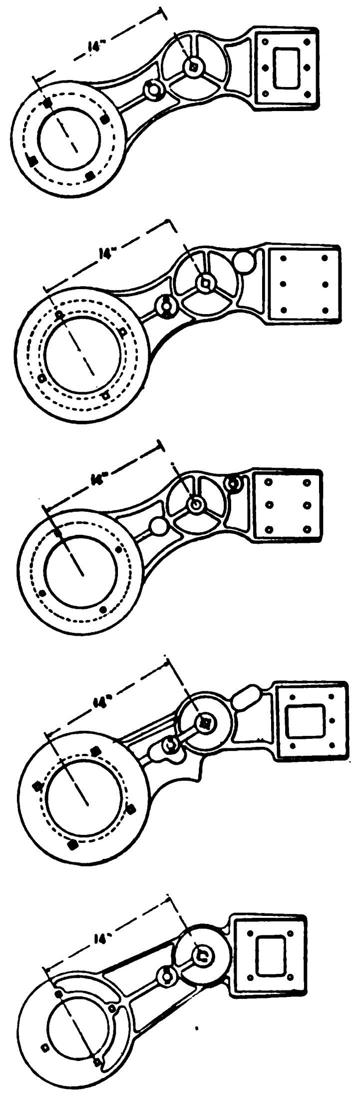
Figs. 2700-2702. Cast Iron Signal Foundation. Michigan Central.



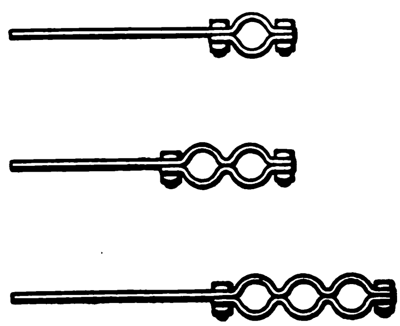
Figs. 2703-2704. Double-Head Disk Signal Mounted on Iron Pipe Post. See Figs. 403-407. Hall Signal Company.

Names of Parts, Hall Double Head Disc Signal; Figs. 2703-2704.

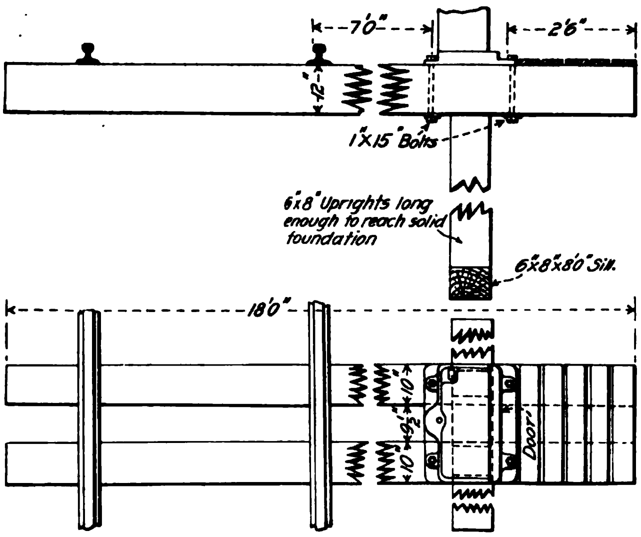
1 *Iron Pipe Post*
2 *Disc Signal Bracket*
3 *Disc Signal Head*
4 *Pinnacle*
5 *U-Bolt*
6 *Ladder*
7 *Ladder Brace*
8 *Number Plate*
9 *Relay Box*
10 *Relay Box Clamp*
11 *Signal Base*
12 *Foundation Bolt*
13 *Wire Plug*
14 *Lamp Bracket*
15 *Trunking Cover*



*Figs. 2705-2709. Types of One-Light Semaphore Castings.



*Figs. 2710-2712. Pipe Guides for Wooden Signal Posts.



Figs. 2713-2714. Timber Foundation for Automatic Block Signals. Southern Pacific-Union Pacific.

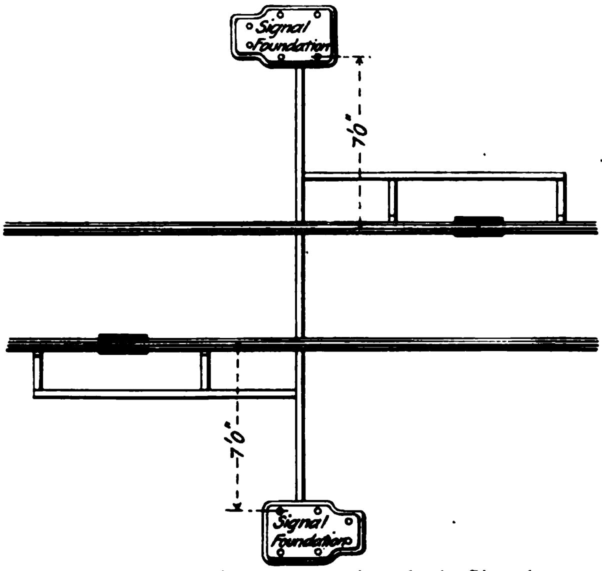


Fig. 2715. Layout for Automatic Block Signals at a Station. Southern Pacific-Union Pacific.

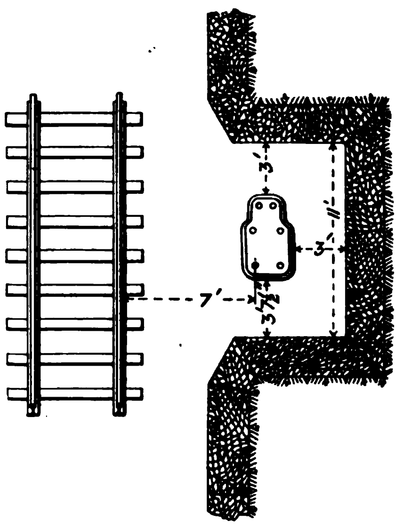
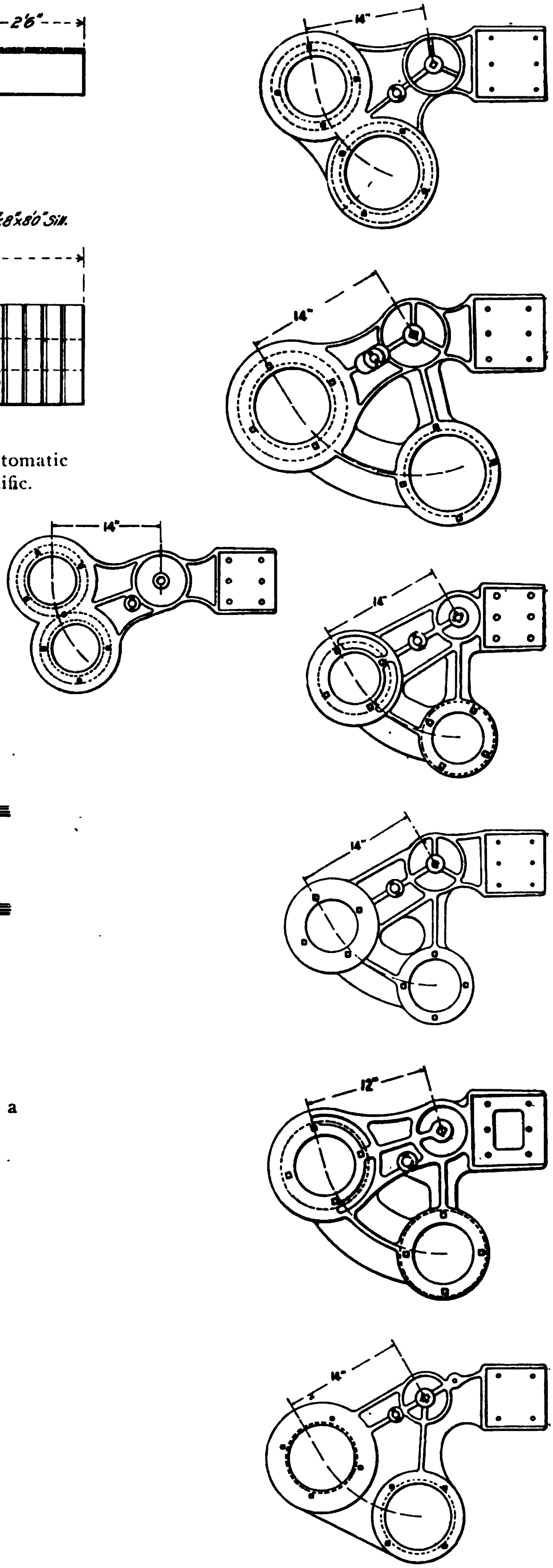


Fig. 2716. Location Plan for Automatic Block Signal in a Cut or on a Fill. Union Pacific.



*Figs. 2717-2723. Types of Two-Light Semaphore Castings.

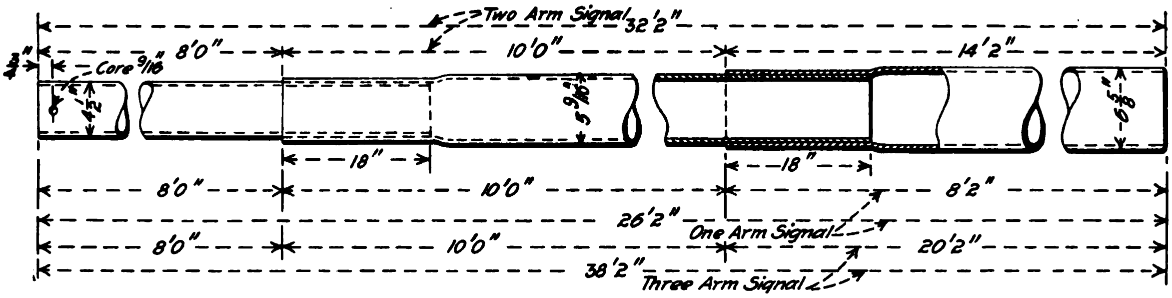
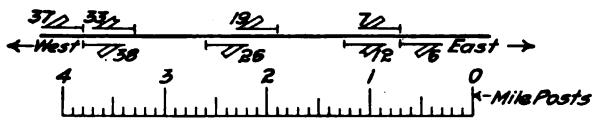
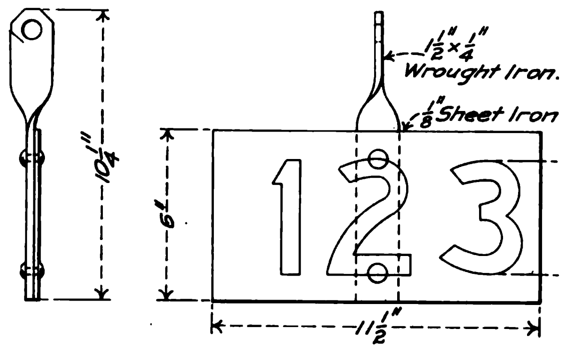


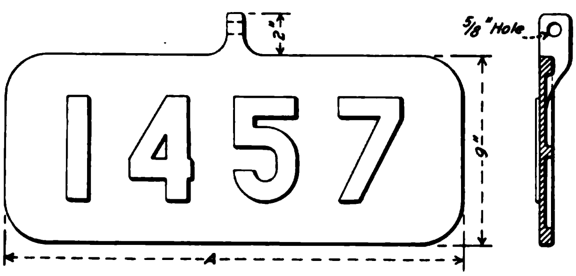
Fig. 2724. Standard Iron Pipe Signal Post. New York Central & Hudson River.



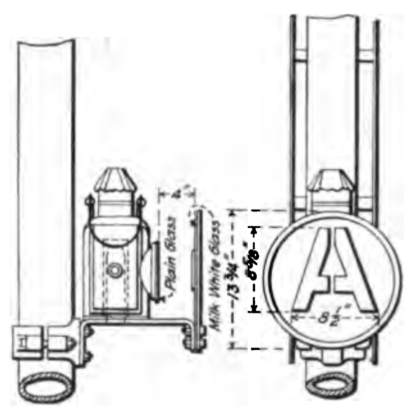
Figs. 2725-2726. Diagram Showing Method of Numbering Automatic Block Signals. Southern Pacific-Union Pacific.



Figs. 2727-2728. Number Plate for Automatic Block Signals. Southern Pacific-Union Pacific.



Figs. 2729-2730. Number Plate for Automatic Block Signals. New York Central & Hudson River.



Figs. 2731-2732. Illuminated Automatic Block Signal Marker. Pennsylvania Railroad.

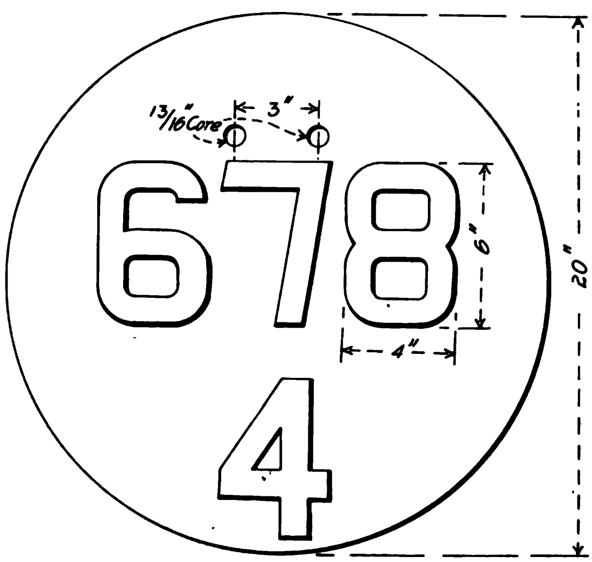
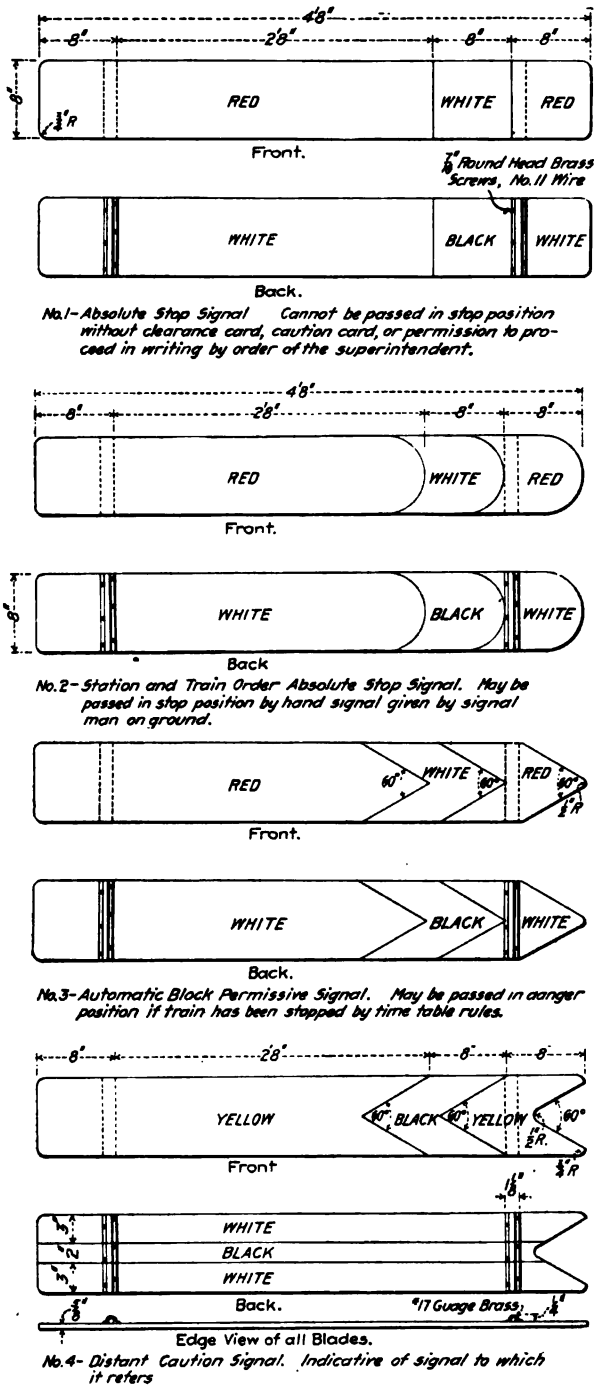
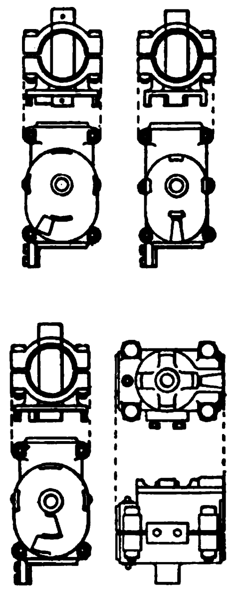


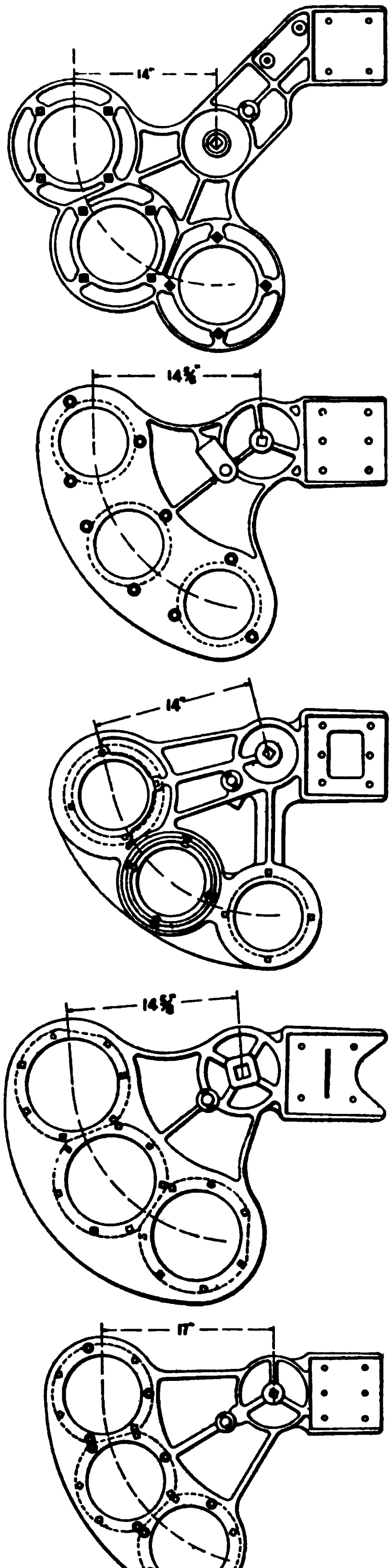
Fig. 2733. Cast Iron Number Plate for Automatic Block Signals. Chicago, Milwaukee & St. Paul.

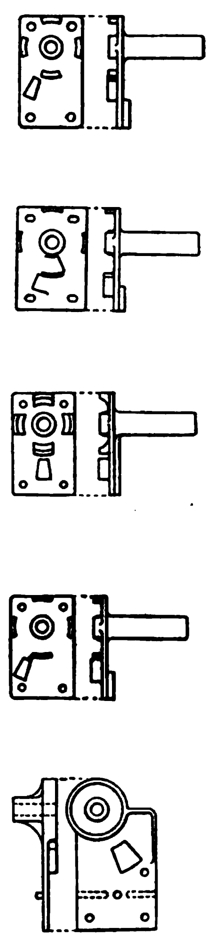


Figs. 2734-2742. Standard Semaphore Blades. New York, New Haven & Hartford.

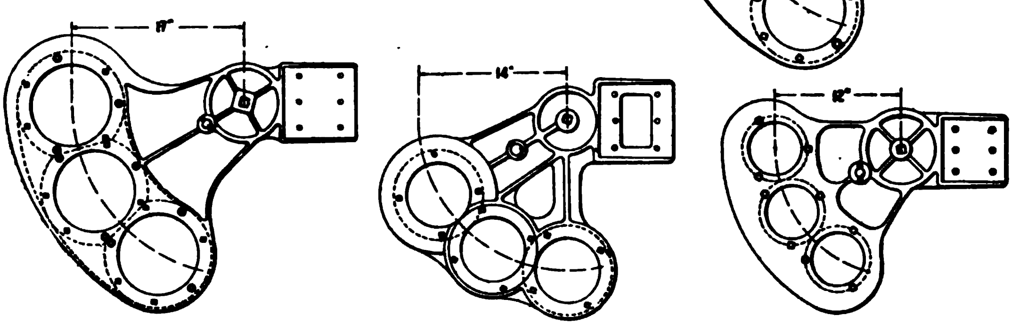


*Figs. 2751-2758. Types of Semaphore Bearings for Iron Pipe Post Outside Connected Signals.





*Figs. 2759-2768. Types of Semaphore Bearings for Wooden Signal Posts.



*Figs. 2743-2750. Types of Three-Light Semaphore Castings.

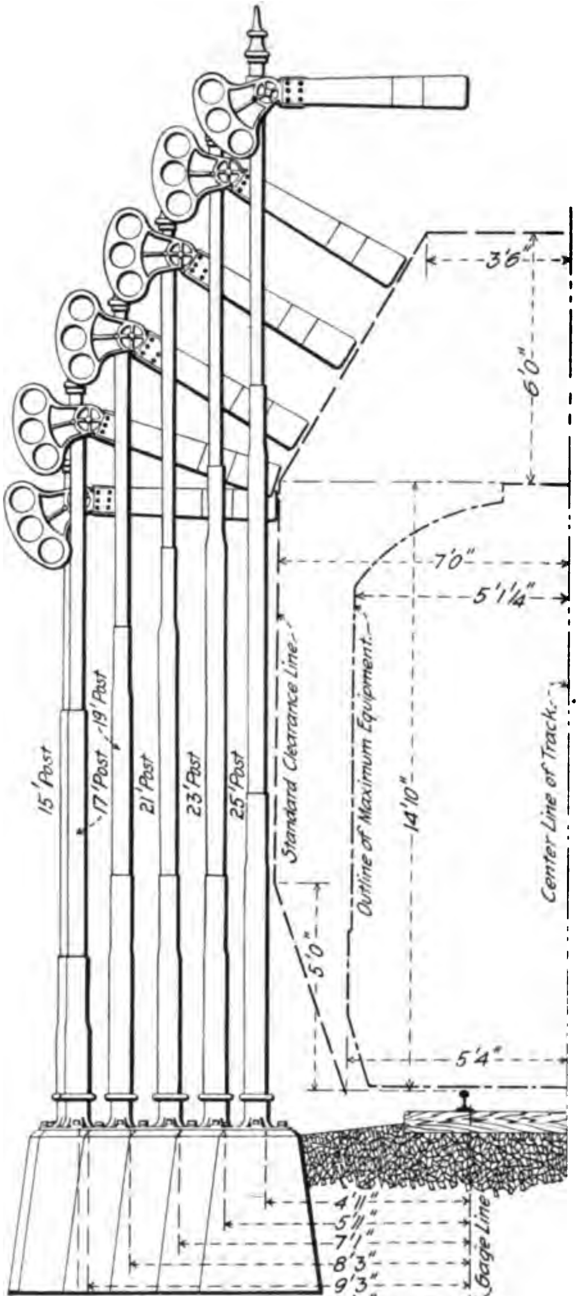
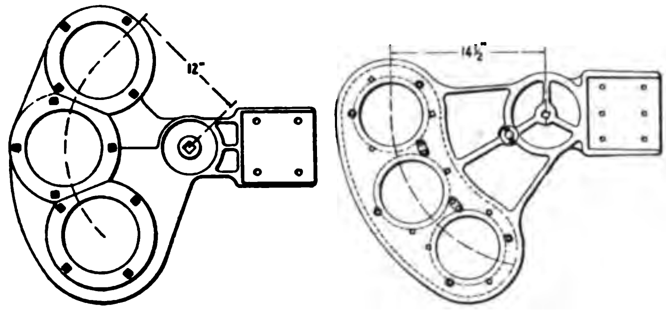
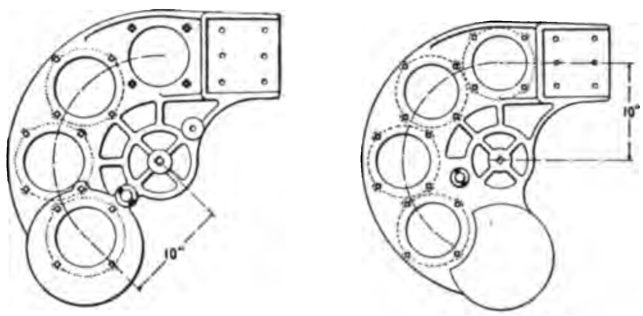


Fig. 2769. Standard Clearance Diagram for Semaphore Signals. New York Central & Hudson River.



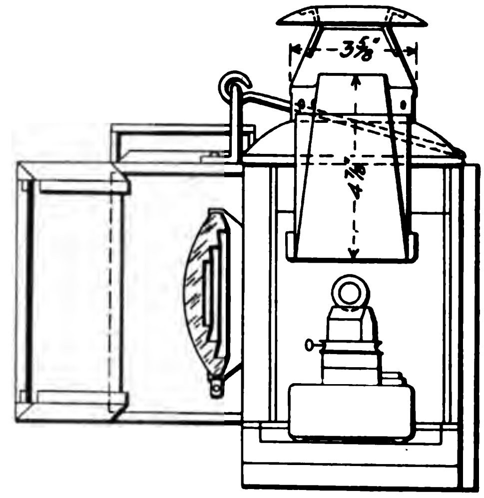
*Figs. 2770-2771. Types of Three-Light Semaphore Castings.

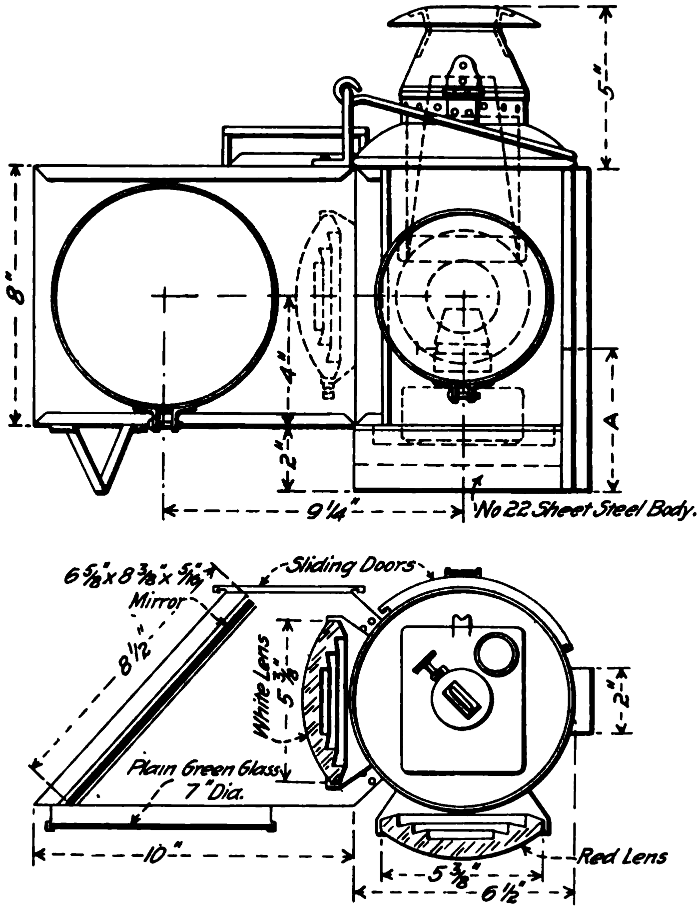


*Figs. 2772-2773. Two Types of "Universal" Semaphore Castings. Four Openings for Roundels Are Provided, So That the Lantern May Be Placed Either on Top of the Post or on One Side.

Fig. 2774. Electric Lamp for Semaphore Lantern. Adams & Westlake Company.

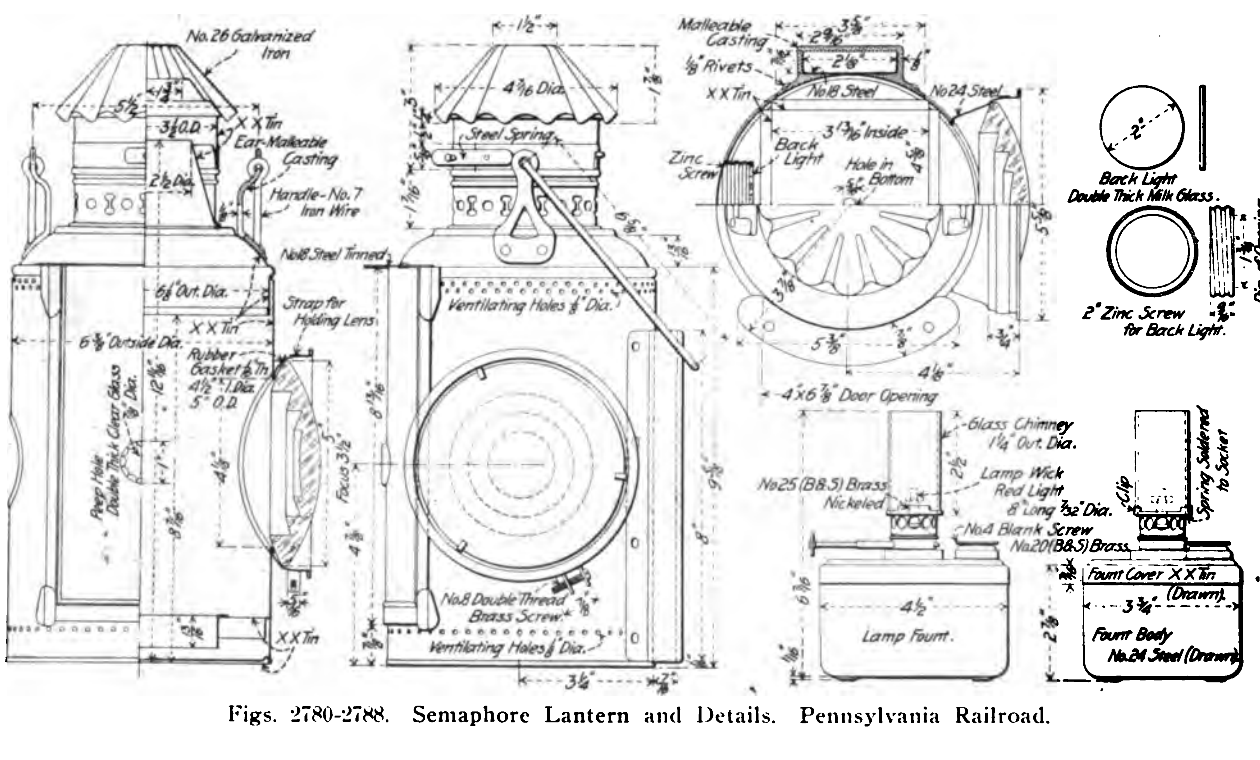
Fig. 2775. Semaphore Lantern. Adams & Westlake Company.





Figs. 2777-2779. Distant Signal Lantern. Chicago & North-Western.

Fig. 2776. Long-Burning Fount with Prismatic Reflector. Adams & Westlake Company.



Figs. 2780-2788. Semaphore Lantern and Details. Pennsylvania Railroad.

Fig. 2789. Twenty-four-Hour Burner. Adams & Westlake Company.

Fig. 2790. Long-Time Burner. Adams & Westlake Company.

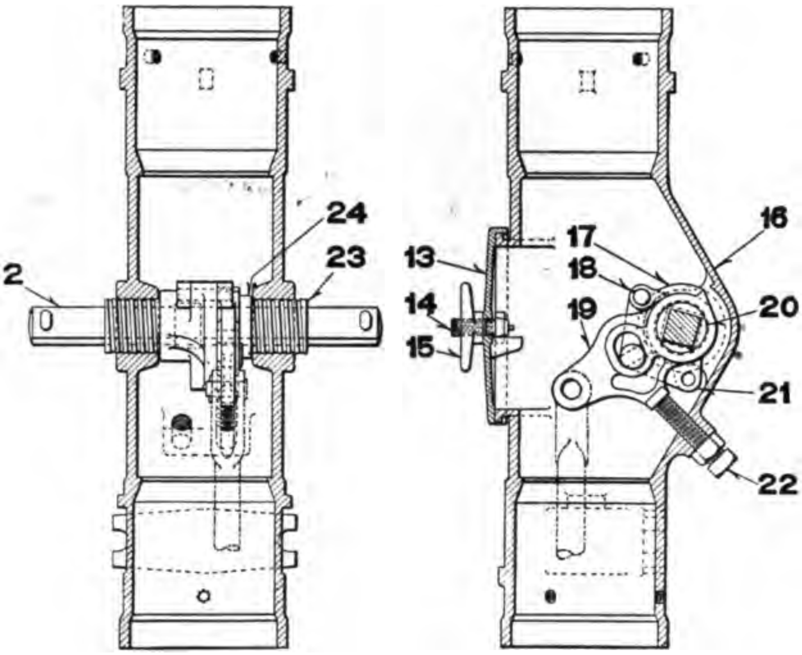
Fig. 2791. Semaphore Lantern. Dressel Railway Lamp Works.

Fig. 2792. Long-Burning Fount with Reflector. Dressel Railway Lamp Works.

Fig. 2793. Long-Burning Fount. Dressel Railway Lamp Works.

Figs. 2794-2798. Semaphore Lanterns and Fittings. Peter Gray & Sons.

Fig. 2799. Twenty-four-Hour Burner. Dressel Railway Lamp Works.



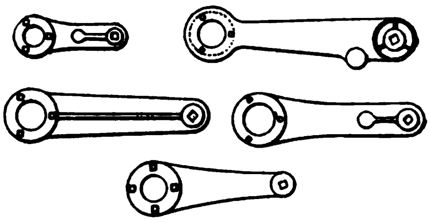
Figs. 2800-2801. Mechanically Locked Semaphore Bearing for 60-Deg. and 75-Deg. Signals. The Union Switch & Signal Company.

Figs. 2800-2803 show a mechanically locked semaphore bearing made by the Union Switch & Signal Company. The object of this device is to prevent a signal from being cleared by any other means than the up and down rod. Figs. 2802-2803 are used for 90° signals. The up and down rod is attached to one end of semaphore crank 11, which has a jaw at its other end. In this jaw rests a lug, at the end of pawl 10. 10 is pinned to segment 8, which rests against a lug on 11. 8 engages with 7 to clear the signal when the rod is raised. If any attempt is made to clear the signal by moving the semaphore casting the lug at the end of 10 will slip out of the jaw and 10 will engage the projection of the bearing casting, thereby preventing movement of the semaphore casting.

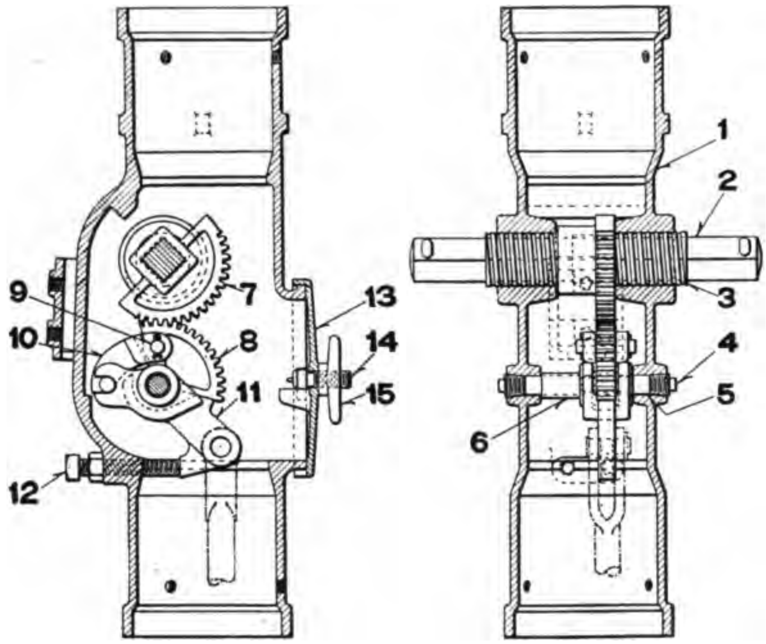
Figs. 2800-2801 are used for 60° and 75° signals. The up and down rod is attached to crank 19, which turns loosely on the semaphore shaft. Casting 21 is rigidly attached to the shaft. It carries a lug which projects through the opening in 19. Pawl 17 is pinned to 21 and rests normally in a depression of the circumference of 19. Any attempt to clear the signal from the semaphore casting will cause 17 to slide out of its seat and engage in the notch of the casting 16, thereby preventing movement of the semaphore casting.

Fig. 445 shows a semaphore bearing made by the American Railway Signal Company. This is for a "pull clear" signal. The pawl is pulled from engagement with the quadrant by the tightening of the chain.

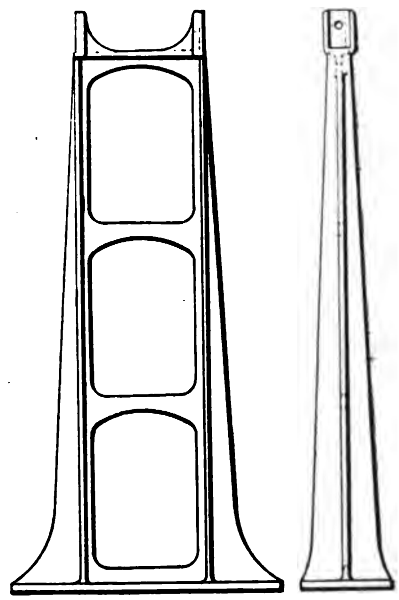
Figs. 408 and 409 show a device for the same purpose made by the Hall Signal Company, as applied to their style F motor mechanism. Catch 34 is rigidly attached to the frame. The up and down rod is pinned to the centrally pivoted pawl on the end of 22. Any attempt to clear the signal from the spectacle will cause the pawl to revolve about its center and engage with 34.



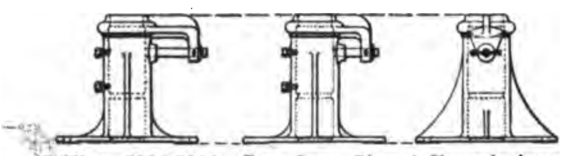
*Figs. 2807-2811. Types of Back Spectacles.



Figs. 2802-2803. Mechanically Locked Semaphore Bearing for 90-Deg. Signals. The Union Switch & Signal Company.



Figs. 2812-2813. Cast Iron Ladder Foundation. The Union Switch & Signal Company.



*Figs. 2804-2806. Cast Iron Signal Foundations and Balance Lever Stands Combined.

Names of Parts Mechanically Locked Semaphore Bearings; Figs. 2800-2803

1 *Semaphore Bearing*
2 *Semaphore Shaft*
3 *Journal*
4 *Pipe Plug*
5 *Shaft for Semaphore Crank*
6 *Semaphore Crank Shaft Separator*
7 *Segment*
8 *Segment*
9 *Pin and Cotters*
10 *Pawl*
11 *Semaphore Crank*
12 *Adjusting Bolt*
13 *Hand-hole Plate*
14 *Hand-hole Plate Clamp*
15 *Handle*
16 *Semaphore Bearing*
17 *Pawl*
18 *Pin*
19 *Female Half of Semaphore Crank*
20 *Bushing*
21 *Male Half of Semaphore Crank*
22 *Adjusting Bolt*
23 *Journal*
24 *Semaphore Shaft Separator*

THE ELECTRO-MECHANICAL SLOT

The electro-mechanical slot, when separate from the signal operating mechanism, is placed in the line of connection to mechanically operated signals in order to insure that a signal will indicate stop even though the lever to which it is connected may not have been restored to the normal position after the passage of a train. It is particularly valuable at the entrance to the first block in a series of controlled manual blocks insuring the restoration of the initial signal to the stop position and its lever to normal after the passage of a train, thus preventing the possibility of other trains following on the same clear indication.

ELECTRO-MECHANICAL SLOT

THE UNION SWITCH & SIGNAL COMPANY

The electro-mechanical slot made by the Union Switch & Signal Company is shown in Figs. 2814-2820. As will be seen from Figs. 2814-2815 the up and down rod, which is moved upward to clear the signal, is carried through an iron box, fixed to the signal post between the signal arm and the balance lever. Referring now to Figs. 2818-2820, the frame K and the parts attached to it move up and down with the rod. The electromagnet M, when energized, keeps rods U and E rigidly connected and the signalman has full control of the signal. When the magnet is de-energized the lifting of the rod U does not lift E, and consequently has no effect on the signal arm. Rod U is connected at its lower end to the balance lever and to frame K at J. Frame K supports the magnet, the guide K', spring L and bolts J and H. The lever G is pivoted so as to move radially on H. Spring T is fixed to the bottom of the case and presses against roller I, in lever G, normally holding the

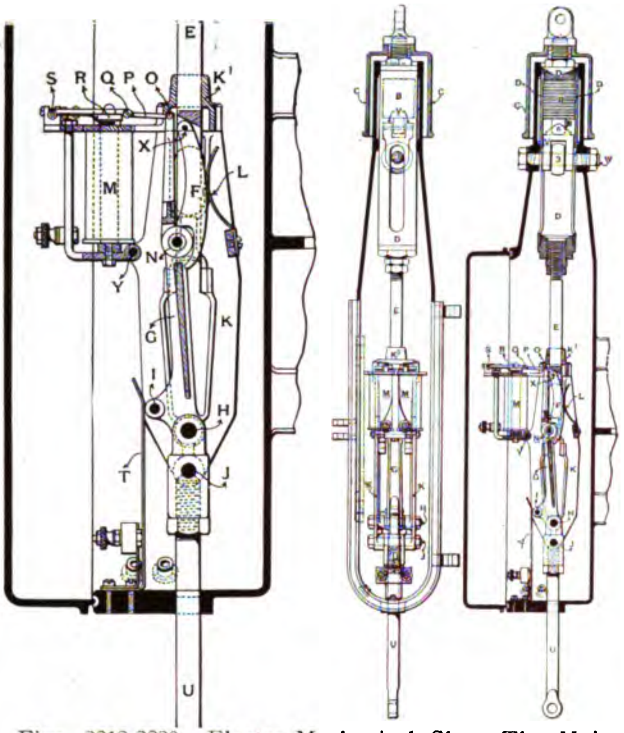
Figs. 2814-2815. Electro-Mechanical Slot and Rotary Circuit Controller Applied to an Iron Pipe Post Signal, Wire Connected. The Union Switch & Signal Company.

Figs. 2816-2817. Electro-Mechanical Slot. The Union Switch & Signal Company.

Names of Parts, **Electro-Mechanical** Slot; Figs. **2818-2820.**

- B *Buffer Piston*
- C *Buffer Shield*
- D *Buffer Cylinder*
- E *Connecting Rod*
- F *Pawl*
- G *Swinging Lever*
- H *Bolt*
- I *Bolt*
- J *Bolt*
- K *Slide Plate Frame*
- K' *Guide*
- L *Spring*
- M *Magnet*
- N *Roller*
- O *Pivot Bolt*
- P *Link*
- Q *Pivot Screw*
- R *Armature*
- S *Pivot Screw*
- T *Spring*
- U *Up and Down Rod*
- V *Jaw*
- W *Bolt*
- X *Pivot Bolt*
- Y *Bolt*

Letters Refer to List of Names of Parts on Preceding Page.



Figs. 2818-2820. Electro-Mechanical Slot. The Union Switch & Signal Company.

latter in position shown. Roller N, in lever G, rests under pawl F, which is pivoted in rod E at X.

The centers H, N and X, are normally (when signal operating lever is normal) out of line. Any upward pressure applied at H consequently tends to move lever G, to the left on H, as a pivot. This causes roller N to move from beneath the pawl F, which is not movable to the left, as a result of the resistance offered by the weight of the semaphore casting pressing downward at X upon pawl F. When magnet M is energized this movement sidewise of G is resisted at O, its upper extremity, as the link P pivoted thereto is held down by the armature R. Pivots S, Q and O are normally out of line, so that when M is de-energized any attempt to move G to the left causes armature R to move upward, the pivot S being fixed, and consequently permits the roller N to move from under pawl F. But if the magnet M is energized its power is ample to hold R down; and thus to prevent the movement of roller N from beneath pawl F. Consequently any upward pressure on U lifts the frame K bodily with all members of the slot engaged as shown, and the signal is thereby cleared. Spring T, being secured to the case ceases to press against lever I the instant this movement begins, and hence its normal tendency to force roller N under pawl F is not present when the signal is clear.

The upper part of the slot is so designed as to provide an air cushion for relieving the shock that would otherwise result when the signal returned automatically to the stop position. Roller 3 is a guide, traveling on the inside of the cylinder, but not at any time touching the surface covered by the piston. When a signal has been put in the clear position, all the movable parts, K, M, F, etc., are in the upper part of the case, and E. D. B, C, etc., are at the upper extremity of their stroke. Point I is free from spring T. Then, when a train passes and, by shunting the track circuit, de-energizes M, the armature R is released and the weight of the semaphore casting, acting through the several members described, forces the roller N from under F. The rod E. with its attachments B, C, D, then drops by gravity, restoring the signal to the stop position. If now the signalman pulls the rod U down again and attempts to clear the signal a second time (before M has been re-energized) he can push up U, J, N, M, etc., but this movement will have no effect on F and E, and the signal will remain in the stop position. When the train goes out of the block section, M is energized and the signalman's control over E, and the signal is restored.

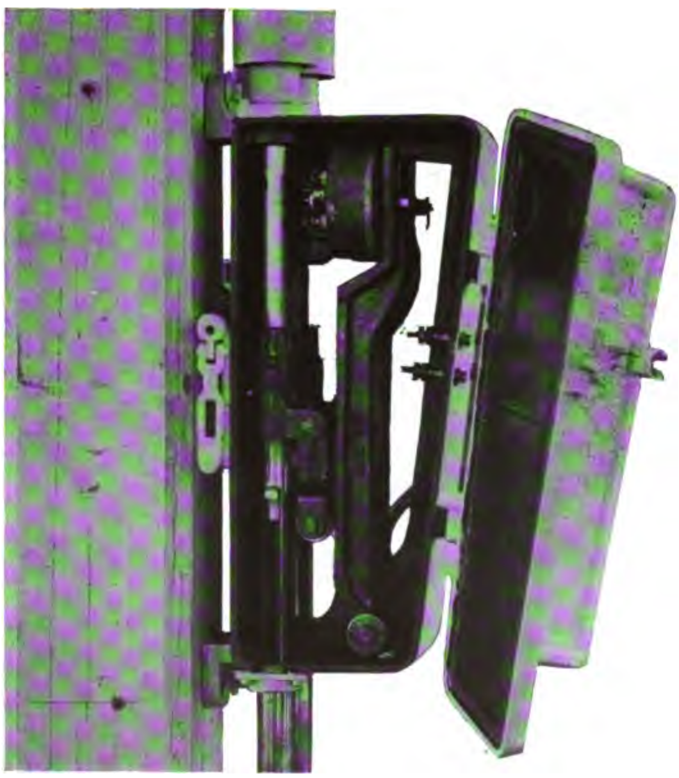


Fig. 2821. Double Electro-Mechanical Slot Mounted on Wooden Post. Hall Signal Company.

ELECTRO-MECHANICAL SLOT

HALL SIGNAL COMPANY

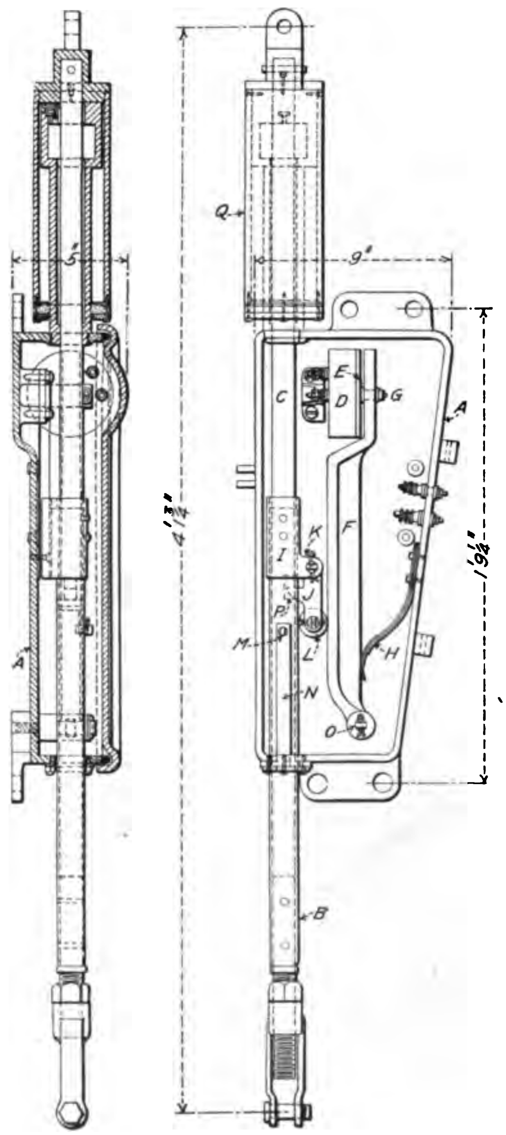
The Hall Signal Company's electro-mechanical slot for semaphore signals, shown in Figs. 2821-2823, is designed to be mounted near the base of the signal post, where it will be easily accessible. All movable parts can be plainly seen and easily inspected or removed without dismembering the entire mechanism. The case is roomy but not over large, and the magnet is fixed. The details and construction are shown in Figs. 2822-2823. In this drawing A represents the cast iron case; B is the lower operating rod, and C the upper operating rod, carrying the dashpot Q, attached in the usual way. D is a powerful iron-clad magnet mounted on a stand which is rigidly fastened to the case; E is the armature secured loosely to the lever F by the threaded pin G. G is slightly smaller than the hole in F, through which it passes, and has a semi-spherical head, after the manner of a ball and socket joint. This is to allow E to make good contact with D, despite any small lack of adjustment in F. Lever F is pivoted at O. H is a phosphor bronze spring used to restore lever F to its normal position, but exerts no appreciable pressure otherwise. I is a cast-iron sleeve riveted to the lower rod B, and carries the latch J, pivoted to the lug K, which is part of the sleeve I; J carries a roller L, to reduce friction when traveling against lever F. The lower end of C extends within B, and carries a pin M, working in slot N, cut in B. This is to allow the signal to be pulled to the stop position, as M projects beyond the edge of B, on both sides. Both rods are notched at P, to allow the projection of latch J to engage with upper rod C. When the magnet D is energized the signal can be cleared. The magnet holds F against latch J by pressing against roller L, and then if B is raised C must also go up, for latch J will engage with lower end of C. If, while the signal is in the clear position, magnet D becomes de-energized the weight of the semaphore casting acting against lever F, through C and latch J, will force F away from D; and J, in tripping, will allow C to pass by, and the signal will assume the stop position. When F is forced away from D it compresses spring H, which remains compressed until B has been restored to its normal position, allowing J again to enter the notch P; when this occurs H restores F to contact with D. If it is attempted to clear the signal when D is de-energized, F will be forced back in the same manner as above described.

The double slot, shown in Fig. 2821, is used where two arms of a signal are slotted, and is much more compact and convenient than two single slots. This slot consists essentially of the mechanism of two single slots mounted side by side in one case, and it operates exactly as above described.

ELECTRO-MECHANICAL SPINDLE SLOT.

GENERAL RAILWAY SIGNAL COMPANY.

The spindle slot made by the General Railway Signal Company is designed to be placed on the spindle of a signal as shown in Figs. 2824-2829. It consists of a circular iron case provided with a lug A, Fig. 2825, to which the up and down rod is attached. This case turns loosely on the spindle. Inside is a circular disk provided with a square hole B, Fig. 2825, in the center for attaching to the spindle. On the disk is mounted the mechanism. This consists of a frame supporting the magnets and a dog in the form of the segment of a circle and a projection. The projection rests normally in a notch in the circumference of the case, Figs. 2827-2829. In the upper part of the frame, is pivoted a lever, whose arms are at right angles. The short arm rests normally against the upper face of the dog. The long arm carries a roller working in a jaw keyed to the pin which carries the armature arm. This pin is supported by a projection on the disk. When the magnet is energized the armature acting through its arm and the jaw and lever holds the dog in the notch, and the signal can be cleared, Fig. 2828. When the magnet is de-energized the counterweight of the signal forces the dog out of the notch and trips the armature, as shown in Fig. 2829. All shock is absorbed by a dash pot mounted on a bracket above the arm casting so arranged that the casting will strike against the piston rod, as shown in Figs. 2824, 2826.



Figs. 2822-2823. Electro-Mechanical Slot.
Hall Signal Company.

Names of Parts, Electro-Mechanical Slot; Figs. 2822-2823.

- **A** *Case*
- **B** *Lower Operating Rod*
- **C** *Upper Operating Rod*
- **D** *Magnet*
- **E** *Armature*
- **F** *Armature Lever*
- **G** *Armature Screw*
- **H** *Restoring Spring*
- **I** *Sleeve*
- **J** *Latch*
- **K** *Lug*
- **L** *Roller*
- **M** *Pin*
- **N** *Slot in* **B**
- **O** *Pin and Cotter*
- **P** *Dog on* **J**
- **Q** *Dash Pot*

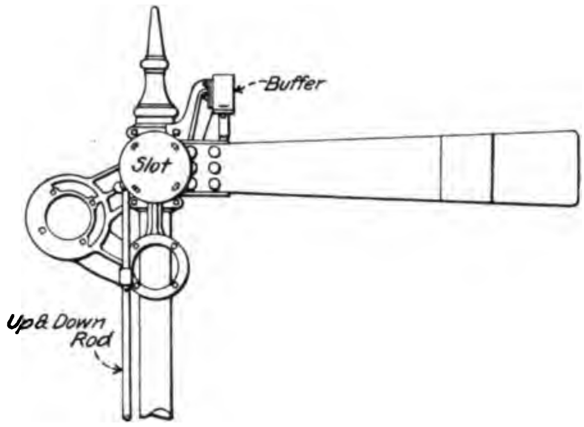


Fig. 2824. Application of Electro-Mechanical Spindle Slot.

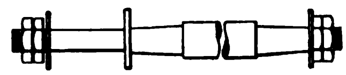


Fig. 2824a. Semaphore Shaft Used with Electro-Mechanical Spindle Slot.

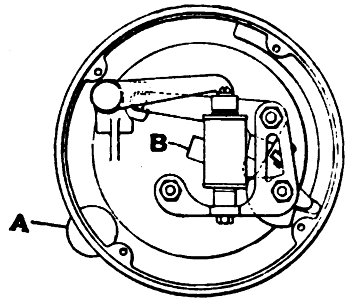


Fig. 2825. Details of Electro-Mechanical Spindle Slot.

Fig. 2826. Application of Electro-Mechanical Spindle Slot.

Fig. 2827. Normal Condition of Electro-Mechanical Spindle Slot.

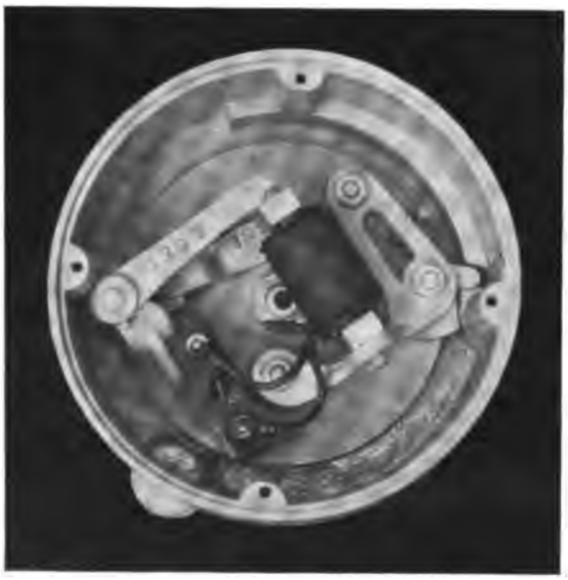


Fig. 2828. Electro-Mechanical Spindle Slot Energized and Signal Clear.

Fig. 2829. Electro-Mechanical Spindle Slot Disengaged; Signal About to Assume the Stop Position.

Figs. 2824-2829. Electro-Mechanical Spindle Slot. General Railway Signal Company.

SWITCH INDICATORS

Where switches occur in block signaled territory they are frequently protected by switch indicators. These may give a visual or audible indication or both. Visual indications are given by an electrically operated semaphore arm or disk mounted in an iron case on a post. Audible indications are given by bells. Indicators are placed near the switch and are controlled by circuits in such a manner as to announce the approach of a train by the horizontal position of the arm, presence of the disk or ringing of the bell when the train is a certain distance away, usually when it is approaching the distant signal for the block in which the switch occurs. When such announcement is given the switch must not be opened until the train has passed.

Figs. 2832-2833 show a semaphore switch indicator made by the Hall Signal Company. The magnet is mounted vertically on a cast iron frame 5, which also forms the base of the instrument. The armature is hinged below the magnet and operates the semaphore arm 3 by operating rod 10. Springs are provided on each side of the cover 7 to hold it firmly to the base. This indicator is designed to be mounted on an iron pipe post.

A second design of semaphore switch or tower indicator (Figs. 2830-2831), made by the Hall Signal Company, is constructed on the same principle as a disk signal (Figs. 403-407). The semaphore arm is mounted on the shaft of a Z armature.

The American Railway Signal Company makes the semaphore switch indicator shown in Figs. 2834-2835. The mechanism is contained in a cast iron case designed to be screwed on top of a pipe post. The magnet is mounted vertically, the armature below, and operates the semaphore arm by an up and down rod and a lever.

Figs. 2836-2842 show the semaphore switch indicator with rotary armature and differential coils, made by the General Railway Signal Company. The armature is of the Z type and actuates the arm direct. There are two windings on the magnet, one of a low resistance, which operates the indicator, and one of high resistance, which, in series with the first, holds the indicator in the clear position. The high resistance is controlled by a circuit breaker on the shaft.

The alternating current switch indicator made by the General Railway Signal Company (Figs. 2843-2845) is constructed exactly like the relay shown in Figs. 496, 521-522, and the tunnel signal shown in Figs. 516-519. It is provided with an electric light mounted on the door, which illuminates the face at night.

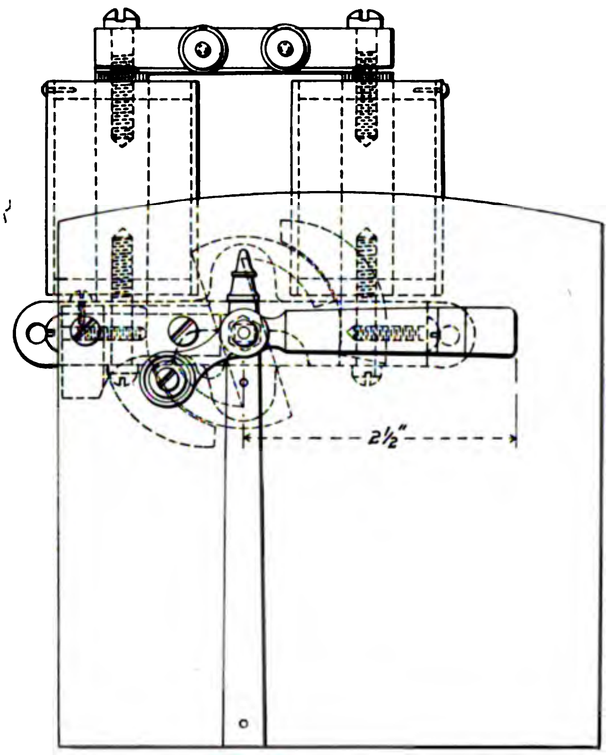
Figs. 2846-2848 show two views and a circuit diagram of the semaphore switch indicator made by the General Electric Company. It has a high and low resistance, the low resistance being the windings of the magnet; the high resistance is contained in two resistance tubes mounted above the mechanism. The magnet is vertical, with the armature below, and operates the semaphore arm by an up and down rod. When the magnet is de-energized, the back point makes a contact which shunts out the high resistance, so that when the armature picks up the high resistance is cut in series with the magnet winding. Thus the indicator will be held clear on a comparatively low current consumption.

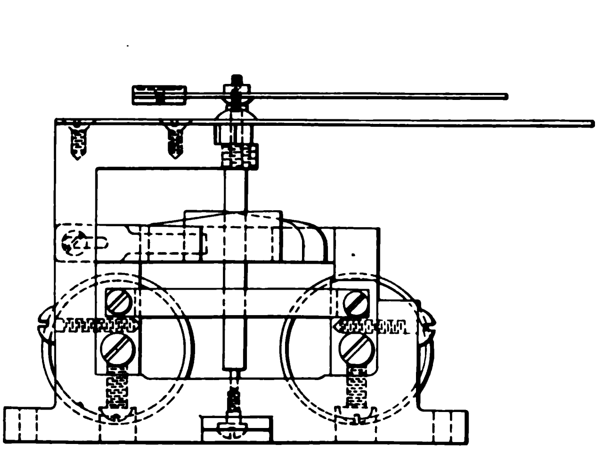
A disk switch indicator, giving night indications, made by the Union Switch & Signal Company, is shown in Figs. 2849-2851. A disk carrying a colored celluloid center is moved in front of the white lens of a lamp by being connected to the Z armature of an electromagnet. The presence of current in the magnet raises the disk to show a clear signal, while the absence of current causes a counterweight to restore the disk to the stop or caution position. This illuminated type is used most frequently in yards where the indicators must be placed at some distance from the switch because of insufficient clearance between tracks for the usual type. These instruments may be used at exits to passing sidings instead of dwarf signals. Wires are brought up through the base and the pipe post. The mechanism is enclosed in an iron case with a removable back.

Figs. 2862-2864 illustrate a semaphore switch indicator made by the Union Switch & Signal Company. It consists of a magnet mounted in an iron case which operates a semaphore arm through its armature and a crank and link. The armature is below the magnet and the semaphore arm is carried on a shaft above the magnet. The shaft projects through a white face plate used as a background for the arm. In the figure is shown a cast iron pipe post and foundation combined.

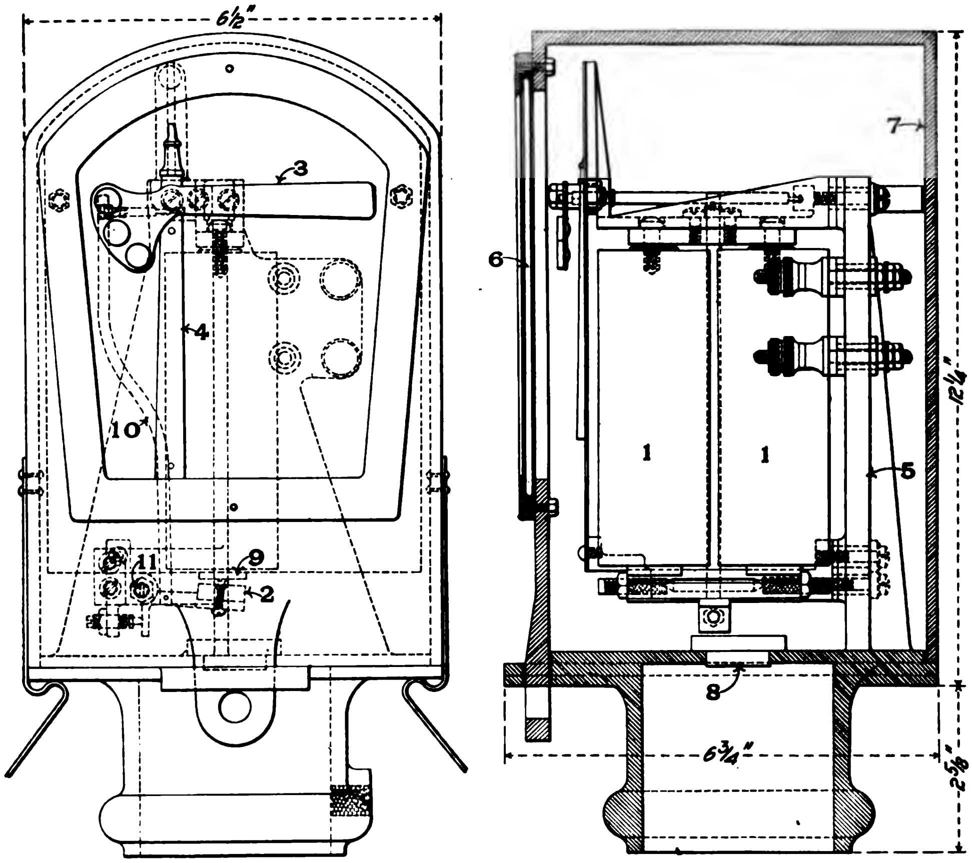
The semaphore switch indicator with bell (Figs. 2852-2854), made by the Union Switch & Signal Company, is in all respects like the indicator shown in Figs. 2862-2864, except for the addition, below the indicator head, of a bell box containing the bell. Two types are shown.

The polarized switch indicator made by the Union Switch & Signal Company, shown in Figs. 2855-2857, consists of an electromagnet between the poles of which is suspended a permanent magnet. When the electromagnet is de-energized the permanent magnet assumes a neutral position, being held by springs. When the electromagnet is energized, the permanent magnet is attracted to one side or the other, according to the direction of the current in the coils of the electromagnet. The permanent magnet actuates a pointer which stands vertical normally and swings to one side or the other in synchronism with the permanent magnet. This type of indicator is designed to cover the field whereby indication at a distance may be had of the condition of two or more devices or mechanisms. It is especially suited to railroad signaling for indicating to a trainman at an outlying passing siding switch: First the approach of a train; second, the movement of the signal controlling the track section in which the switch occurs, to a position corresponding to that of the outlying switch. In automatic block signaling it may be desirable that a trainman have positive information relative to main line conditions when about to open a switch leading to the main line, and having opened such switch, that the main line signal has moved to the stop position, and that the opening of the switch was the cause of setting the signal. The ordinary neutral type of indicator does not fulfil these conditions. Should a train enter the main line section at the instant the switch was opened by a trainman, it is possible that the trainman might assume that his act of opening the switch had set the main line signal and his train would move out onto the main line, which might cause delay to an approaching train; or he might assume that a train was at the setting section for the indicator and move out onto the main line expecting the approaching train to be held at the home signal, when in reality the approaching train had passed the signal and was in the





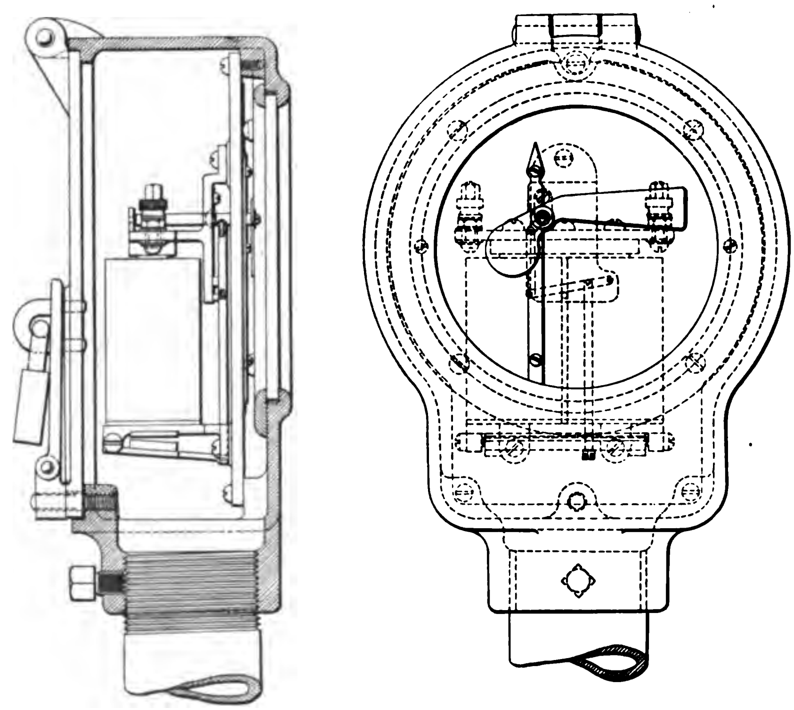
Figs. 2830-2831. Semaphore Switch or Cabin Indicator. Hall Signal Company.



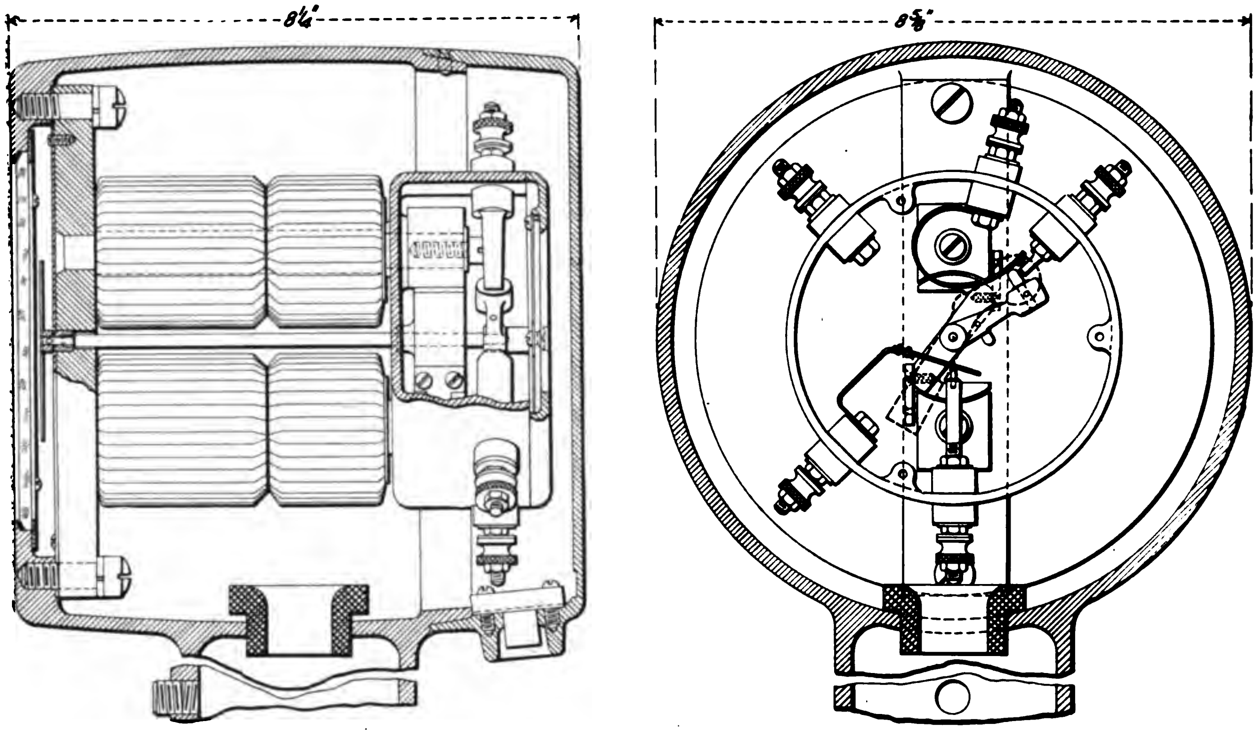
Figs. 2832-2833. Semaphore Switch Indicator. Hall Signal Company.

Names of Parts, Hall Semaphore Switch Indicator; Figs. 2832-2833.

1 *Magnet.*	5 *Magnet Frame*	9 *Pole Piece*
2 *Armature*	6 *Glass*	10 *Operating Rod*
3 *Semaphore Arm*	7 *Cover*	11 *Trunnion Screw*
4 *Post*	8 *Wire Plug*	

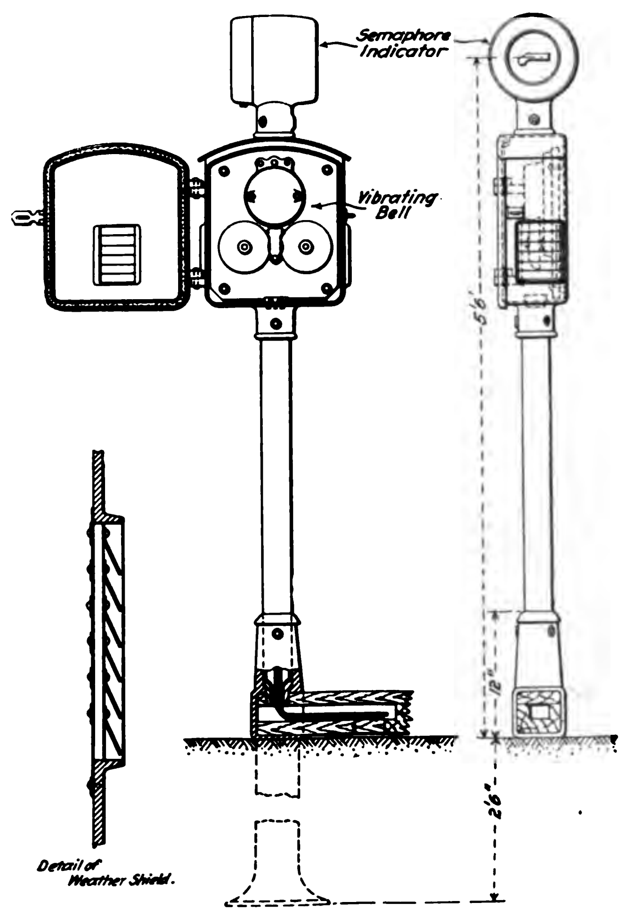


Figs. 2834-2835. Semaphore Switch Indicator. American Railway Signal Company.

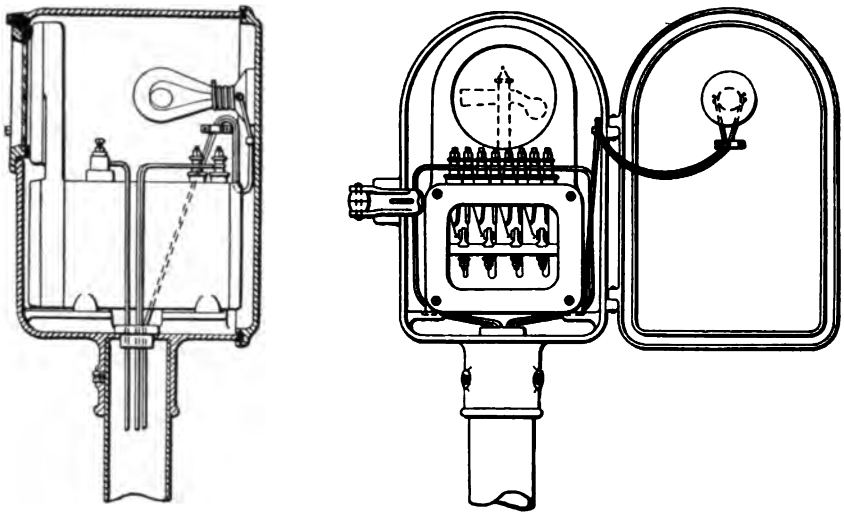


Figs. 2836-2837. Details of Figs. 2838-2839.

Figs. 2838-2839. Semaphore Switch Indicator with Rotary Armature and Differential Coils. General Railway Signal Company.



Figs. 2840-2842. Same as Figs. 2836-2839, with Bell Added.



Figs. 2843-2844. Illuminated, Alternating Current, Semaphore Switch Indicator. General Railway Signal Company.

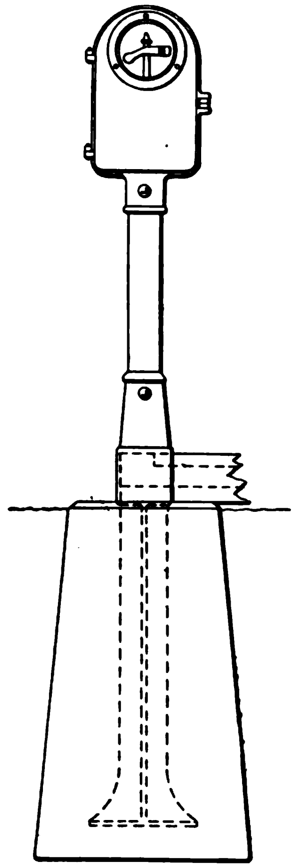


Fig. 2845. Semaphore Switch Indicator, Figs. 2843-2844, Mounted on Iron Pipe Post Set on Cast Iron Base, Embedded in Concrete Foundation. General Railway Signal Company.

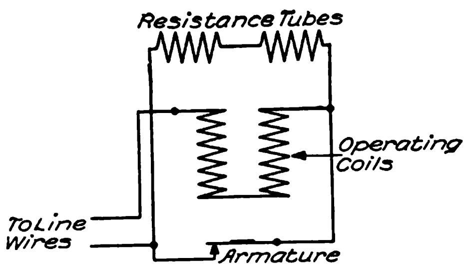
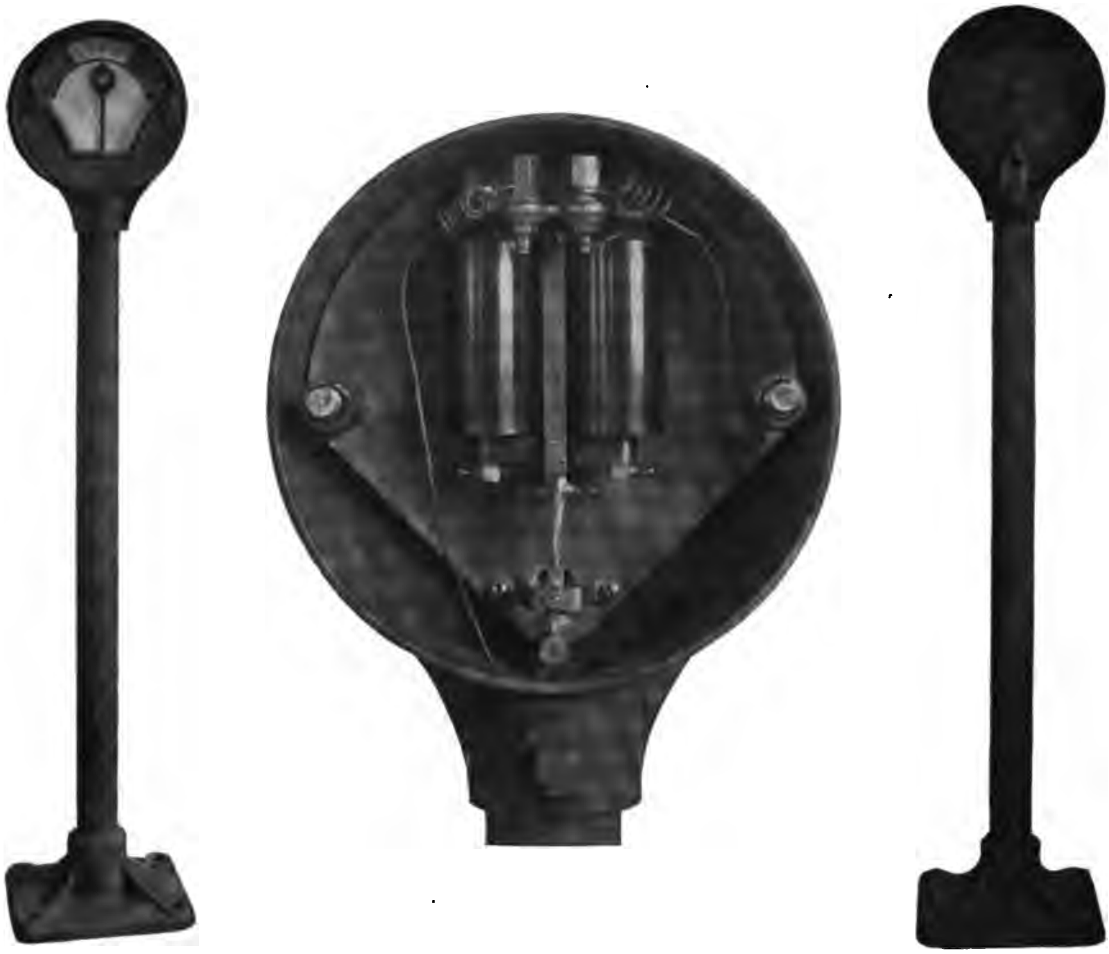


Fig. 2846. Diagram of Circuits for Semaphore Switch Indicator, Figs. 2847-2848.

Figs. 2847-2848. Semaphore Switch Indicator. General Electric Company.

Figs. 2852-2854. Semaphore Switch Indicator with Bell. See Figs. 2862-2864. The Union Switch & Signal Company.

Figs. 2849-2851. Illuminated Disk Switch Indicator. The Union Switch & Signal Company.



Figs. 2855-2857. Polarized Switch Indicator Mounted on Iron Pipe Post. The Union Switch & Signal Company.

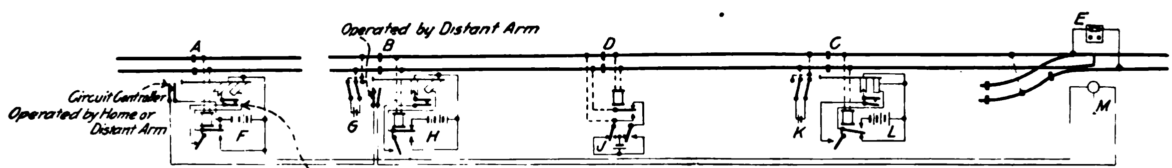


Fig. 2858. Circuits for Switch Indicator; Signals Installed on "Wireless" System. The Union Switch & Signal Company.

block containing the passing siding switch, thereby causing a collision risk. It may be used at slotted signals of interlocking plants to indicate an approaching train, the clearing of the signal and the return of the signal to the stop position, or it may be used to indicate whether or not a signal light, not visible, is in proper condition at night, and for other similar purposes.

Figs. 2859-2860. Siding Bell Box. Railroad Supply Company.

Fig. 2861. Semaphore Switch Indicator. Railroad Supply Company.

Figs. 2862-2864. Semaphore Switch Indicator. The Union Switch & Signal Company.

Fig. 2865. Semaphore Switch Indicator with Bell. Railroad Supply Company.

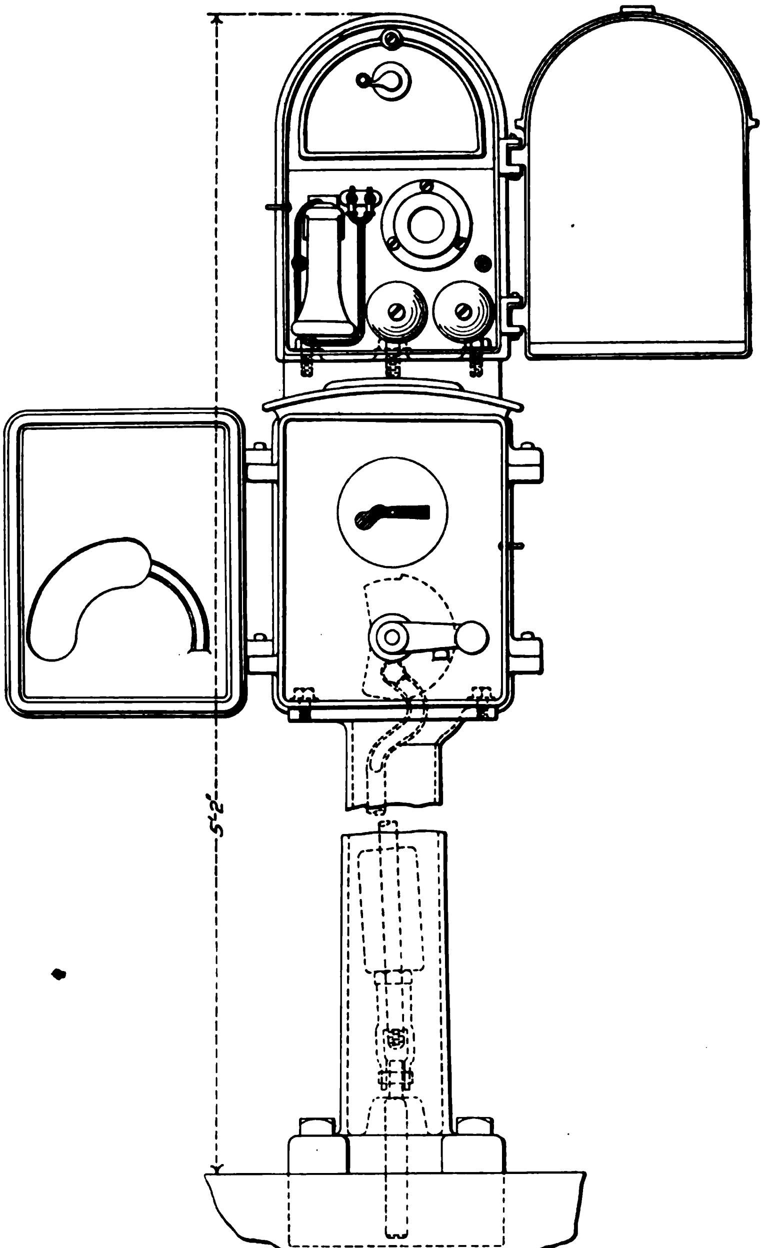
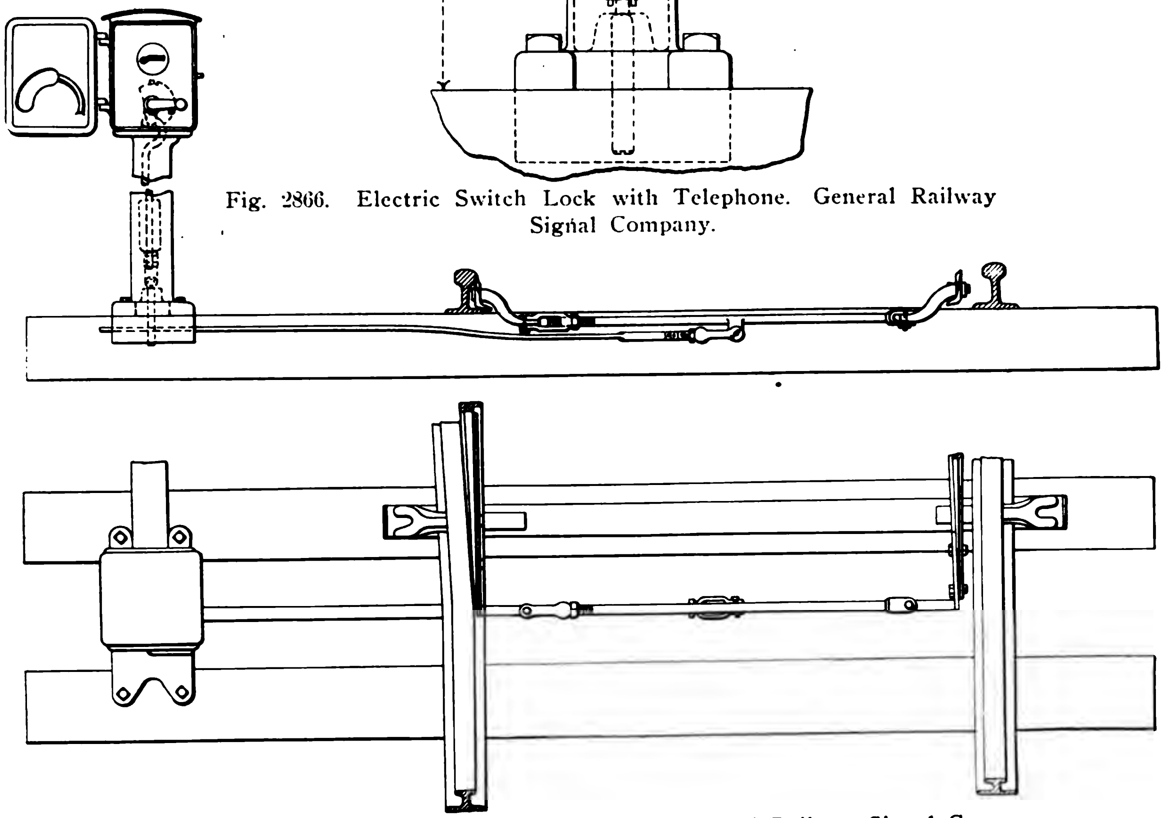


Fig. 2866. Electric Switch Lock with Telephone. General Railway Signal Company.



Figs. 2867-2868. Electric Switch Lock in Place. General Railway Signal Company.

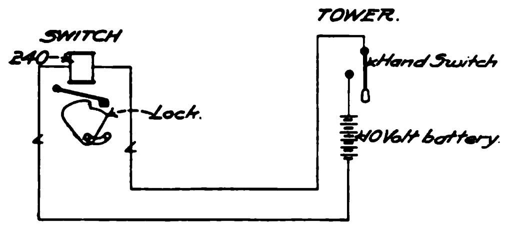


Fig. 2869. Circuit for Electric Switch Lock. General Railway Signal Company.

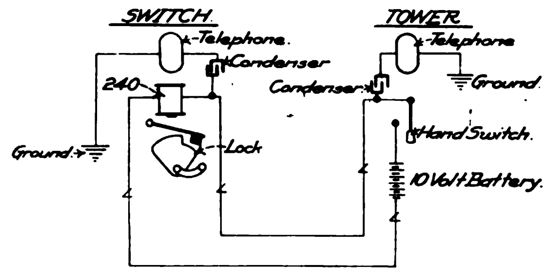


Fig. 2870. Circuits for Electric Switch Lock, with Telephone. General Railway Signal Company.

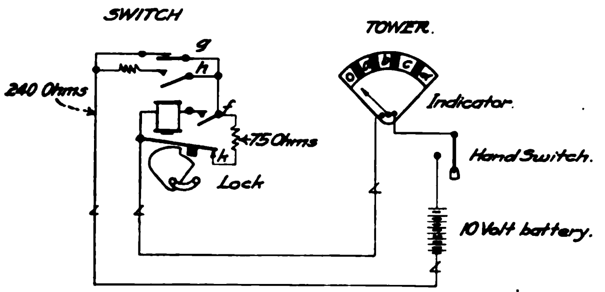


Fig. 2871. Circuits for Electric Switch Lock, with Repeater. General Railway Signal Company.

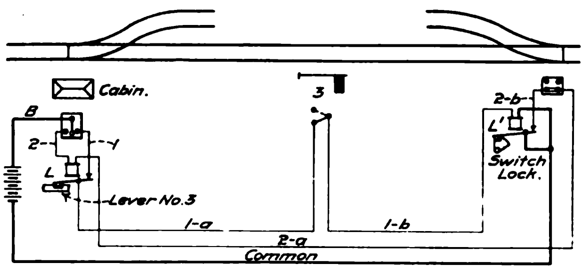


Fig. 2872. Circuits for Outlying Electric Switch Lock at Block Station. Erie Railroad.

NOTE.

Indicator Needle at a = Switch unlocked.
" " " b = Lock door open.
" " " c = Switch locked in normal position.
" " " d = Something out of order.
" " " o = Something out of order.

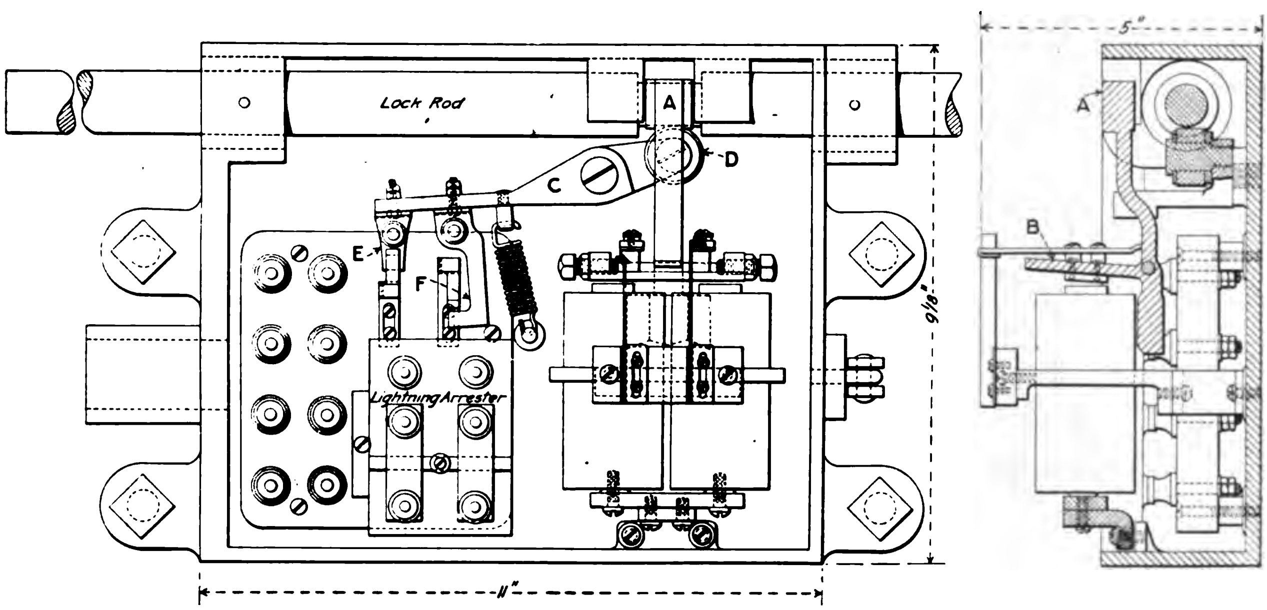
f = Contact, operated by lock door, made when door is open.
g = Contact, operated by lock handle, broken when switch is unlocked.
h = Contact, operated by lock handle, made when switch is unlocked.
k = Back contact on lock armature.

ELECTRIC SWITCH LOCKS

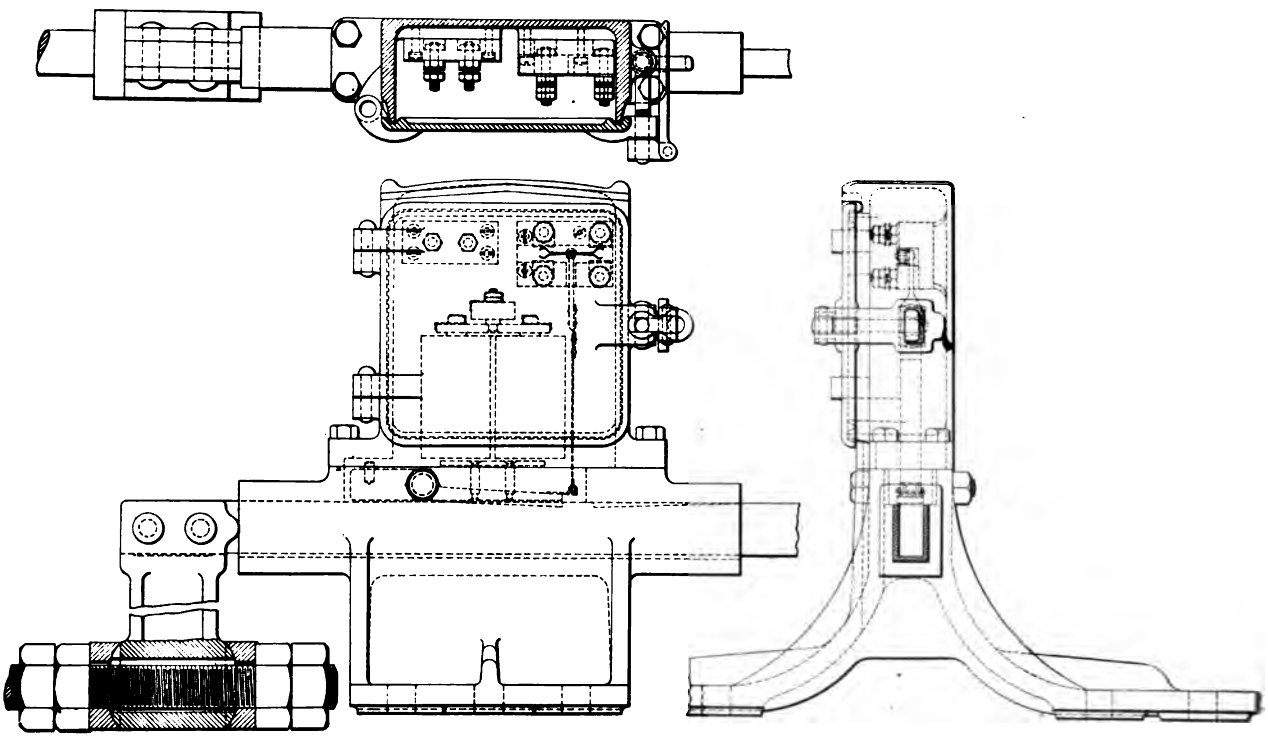
In Figs. 2867-2869 are shown a switch lock made by the General Railway Signal Company applied to a switch and a control circuit for operating it. The switch lock consists primarily of a weighted vertical plunger, designed to pass through a hole in the switch lock rod, actuated by a hand lever. On the same shaft with the lever is a notched quadrant so arranged that a dog attached to the armature of an electro-magnet will drop into the notch and hold the apparatus immovable when the magnet is de-energized and the plunger down. A small semaphore indicator is provided to give visual indication of the condition of the magnet. The whole is mounted in an iron box set on an iron post.

Fig. 2866 illustrates a further development of the switch lock shown in Figs. 2867-2868. Here a telephone is added mounted in a box above the switch lock so that trainmen may communicate with the operator, who controls the lock and who has a telephone in his office connected to the one at the switch. See Fig. 2870.

Letters Refer to List of Names of Parts on Following Page.



Figs. 2873-2874. Electric Switch Lock. Hall Signal Company.



Figs. 2875-2877. Electric Switch Lock, Fig. 2878. American Railway Signal Company.

Names of Parts, Electric Switch Lock; Figs. 2873-2874.

A *Armature Lever and Latch Dog*
B *Armature*
C *Circuit Controller Arm*
D *Roller*
E *Front Contact Arm*
F *Back Contact Arm*

Fig. 2878. Electric Switch Lock. American Railway Signal Company.

Fig. 2879. Electric Switch Lock. The Union Switch & Signal Company.

Fig. 2880.

Fig. 2881.

Figs. 2880-2881. Electric Switch Lock. Railroad Supply Company.

Fig. 2882. Telegraph Key.

Fig. 2883. Telegraph Sounder.

Fig. 2884. Telegraph Relay.

Western Electric Company.

Fig. 2885. Telegraph Jack. Western Electric Company.

Fig. 2886. Hand Michrophone and Receiver Set. Central Electric Company.

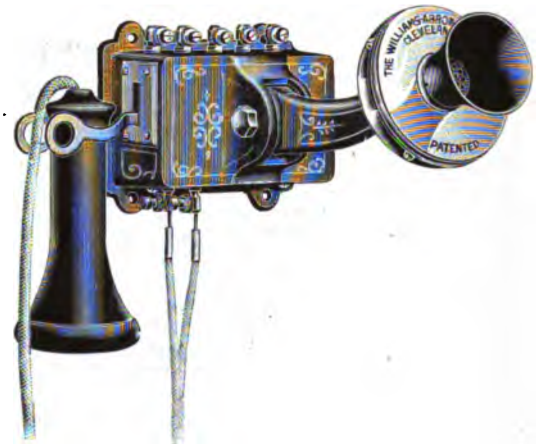


Fig. 2887. Triplet Wall Talking Set. Central Electric Company.

Fig. 2888. Telephone Wall Set. Western Electric Company.

Fig. 2889. Mechanical Time Lock. The Union Switch & Signal Company.

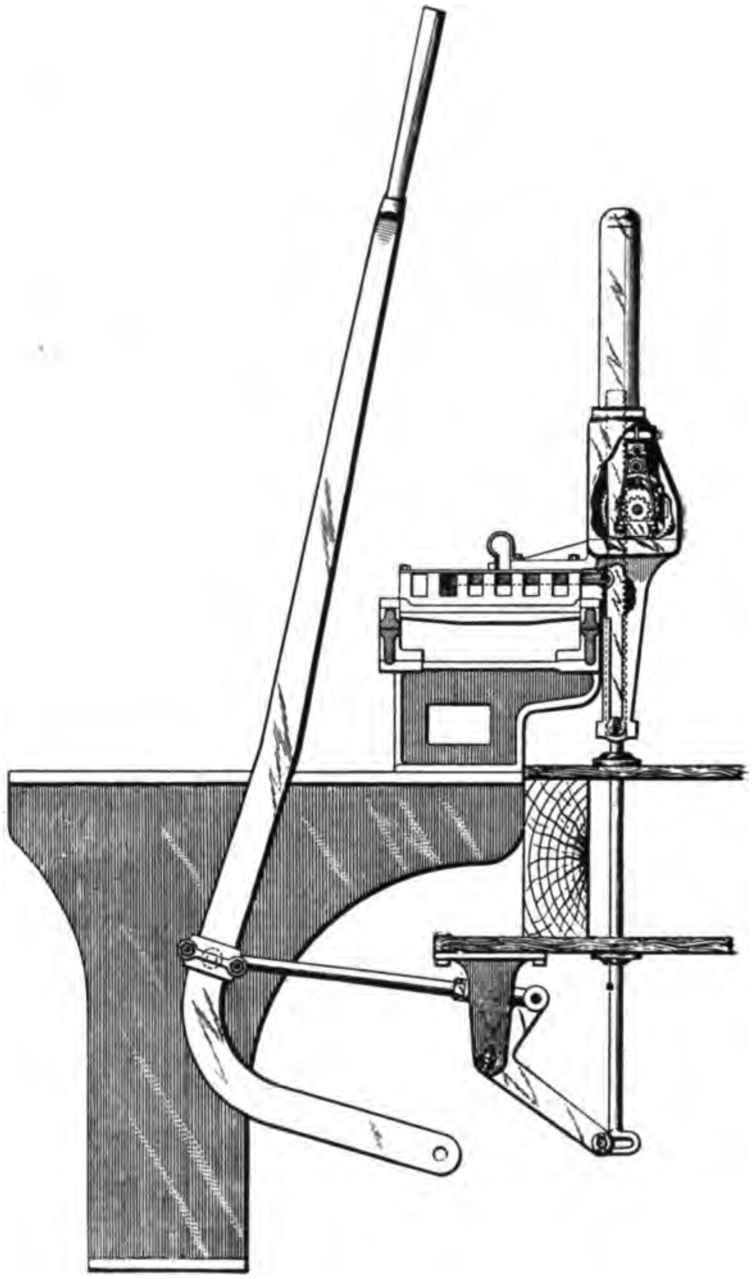


Fig. 2890. Mechanical Time Lock Applied to a Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.

MECHANICAL TIME LOCKS

Mechanical time locks are employed with interlocking machines to introduce a time element between placing signal or other levers normal, and any change in the route for which the signal or other function was reversed. They are used instead of electric track circuit approach locking and are operative for every movement of the signal or other lever.

Fig. 2889 shows the mechanical time lock made by the Union Switch & Signal Company. The contact of the lever locking is secured by engagement with an extra piece of cross locking driven by a bar in the time lock vertically moved as the lever is reversed. A rack on this bar engages a gear wheel connected to a ratchet and escapement in such a manner as to permit a quick movement of the lever to the reversed position to lock the switch levers but requiring a slow movement consuming one minute or more to place the lever normal, lower the bar and release the switch locking.

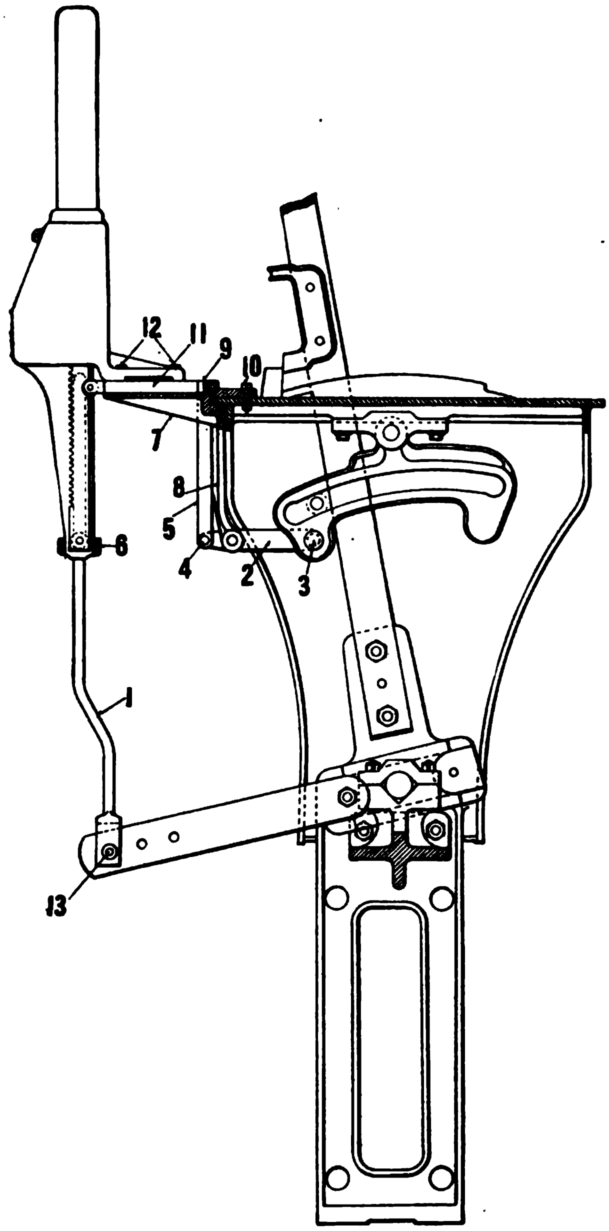


Fig. 2891. Mechanical Time Lock Applied to a National Interlocking Machine. The Union Switch & Signal Company.

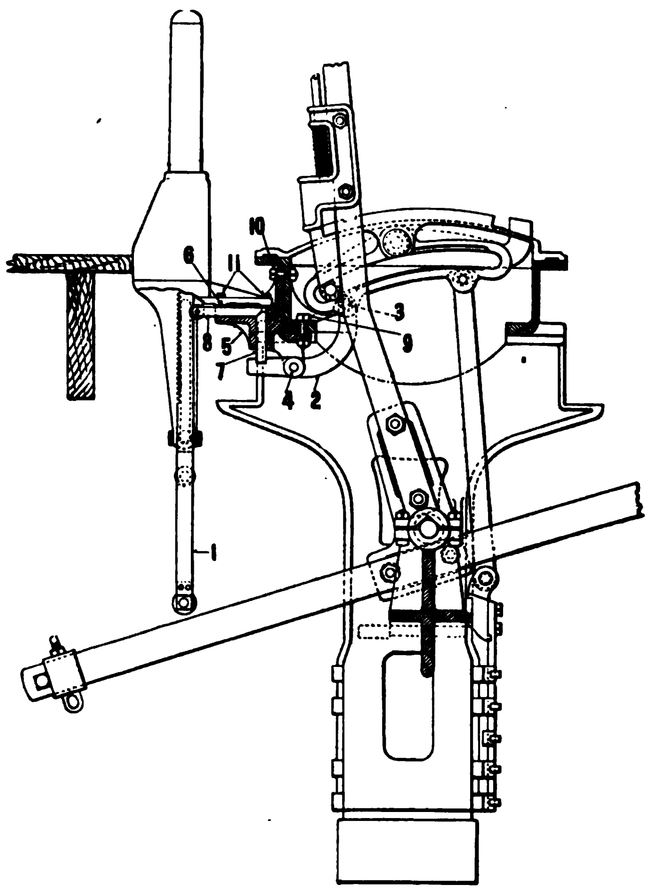


Fig. 2892. Mechanical Time Lock Applied to a Standard Interlocking Machine. The Union Switch & Signal Company.

Names of Parts, Mechanical Time Lock Applied to National Interlocking Machine; Fig. 2891.

1 *Operating Rod with Jaw*
2 *Lever*
3 *Stud*
4 *Pin and Cotter*
5 *Locking Bar*
6 *Guide*
7 *Bracket*
8 *Bracket for Supporting 5*
9 *Cross Locking*
10 *Bolt*
11 *Cross Locking Dog*
12 *Cap Screw*
13 *Pin and Cotter*

Names of Parts, Mechanical Time Lock Applied to Standard Interlocking Machine; Fig. 2892.

1 *Vertical Locking Bar and Rack*
2 *Locking Lever*
3 *Rocker Pin and Cotter*
4 *Locking Lever Pin and Cotter*
5 *Bracket*
6 *Sheet Steel Cover for 5*
7 *Locking Pin*
8 *Cross Lock Rod*
9 *Tap Bolt*
10 *Tap Bolt*
11 *Tap Bolt*

TIME RELEASES

Slow hand or time releases are employed in connection with electric locks on interlocking machines to release mechanically the electric locks after an operation. They require from 20 seconds to two minutes to operate. The operation may also mechanically lock certain levers so as to insure the return of the device to the normal position to unlock such levers. Hand releases are usually employed at an interlocking plant having approach locking, to release such locking in case of emergency when it has become effective because of the approach of a train and a change of route is necessary.

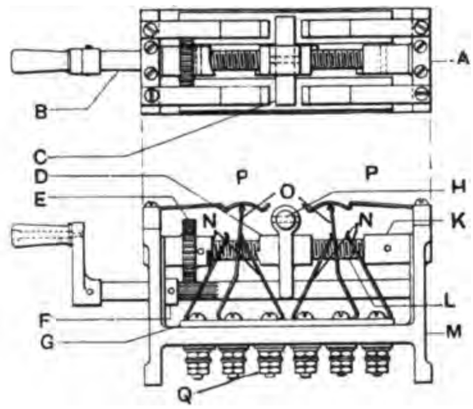
The screw hand release, Figs. 2893-2895, is made by the General Railway Signal Company. Circuits may be controlled by this device. When the apparatus is normal the crosshead is at the extreme left hand end at screw L. When in this position insulated pin H has forced the left hand center contact O against the side contact spring N and the head of O will be held by the notch in retaining spring P. It cannot slip out of this notch and break the circuit until H strikes against the end of P, thereby raising it. When the apparatus is in the full reverse position the right hand set of contact springs is operated in the same manner by H. Thus, it is necessary to operate the device through its full stroke forward and back in order to accomplish a release and restore the circuits. As the center contact springs O snap from their extreme positions a quick break is accomplished avoiding an arc. See Figs. 2019-2016.

Figs. 2896-2897 show the application of a mechanical screw release to an interlocking machine with vertical locking. The release actuates an extra tappet carrying a special dog which drives a piece of cross locking. This piece of cross locking is provided with a wedge which enters the lock box and raises the dog in the lock from engagement with the locking of the machine. The piece of cross locking will butt against and hold all the locking having to

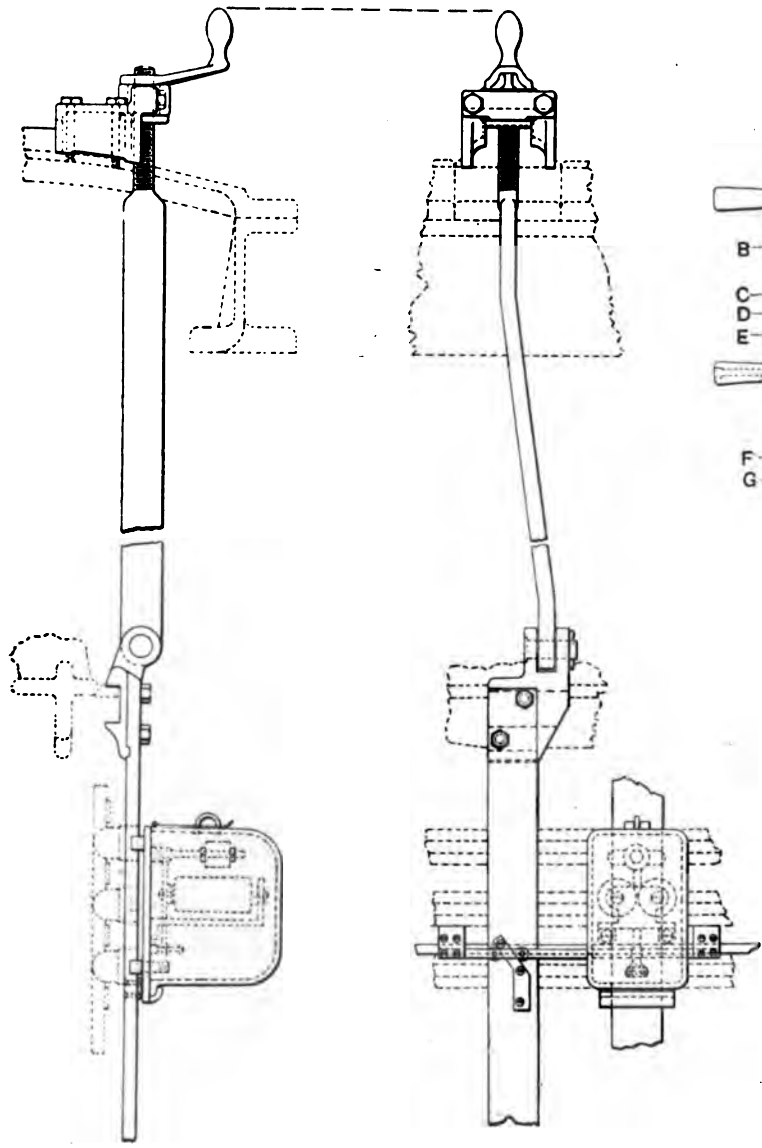
Fig. 2893. Electrical Screw Hand Release. General Railway Signal Company.

Names of Parts, Screw Hand Release; Figs. 2894-2895.

A *Insulating Block*
B *Pinion Shaft with Handle*
C *Crosshead Insulator*
D *Crosshead*
E *Gear Wheel*
F *Collar*
G *Contact Post Insulator*
H *Pin*
K *Back Sleeve*
L *Operating Screw*
M *Frame*
N *Side Contact Spring*
O *Center Contact Spring*
P *Retaining Spring*
Q *Binding Posts*



Figs. 2894-2895. Electrical Screw Hand Release. General Railway Signal Company.



Figs. 2896-2897. Mechanical Screw Hand Release Applied to an Interlocking Machine with Vertical Locking. General Railway Signal Company.

Fig. 2898. Electro-Mechanical Screw Hand Release. General Railway Signal Company. For Applications See Figs. 1782, 2014.

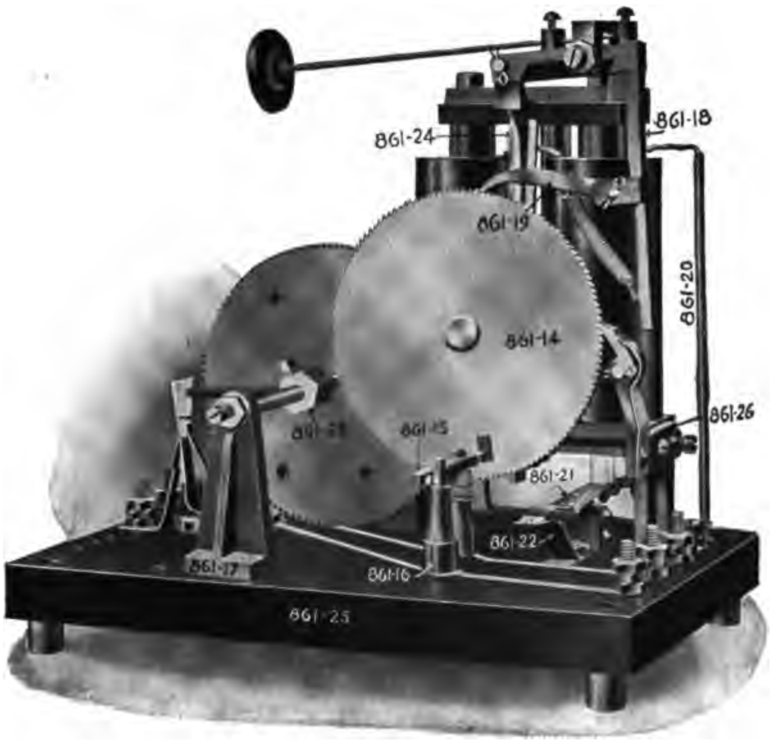


Fig. 2899. Front View.

Fig. 2900. Contacts; Front Contact Closed, Back Contact Open.

Fig. 2901. Contacts; Back Contact Closed, Front Contact Open.

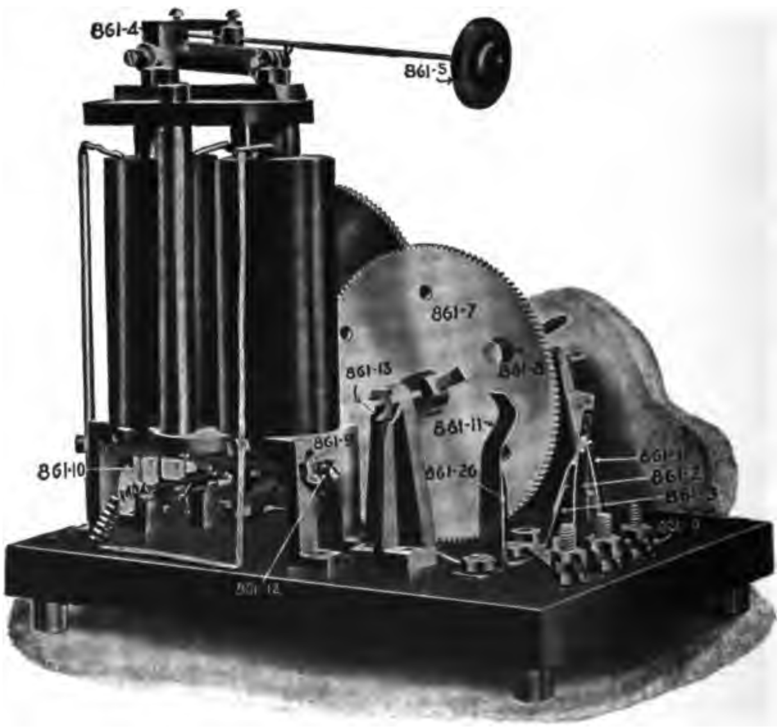


Fig. 2902. Rear View.

Figs. 2899-2902. Electrical Time Circuit Breaker. Railroad Supply Company.

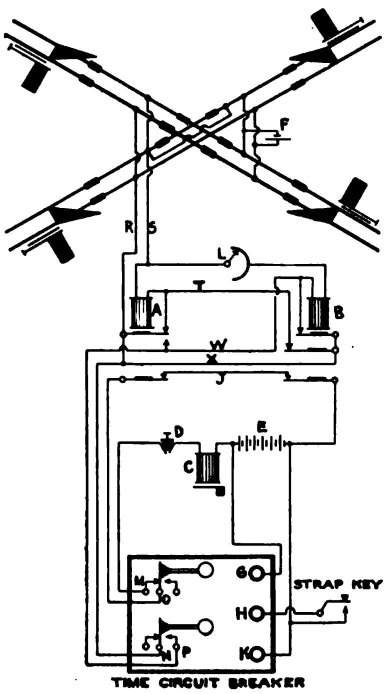


Fig. 2903. Electrical Time Circuit Breaker Used as Time Release for Route Locking Circuits. Railroad Supply Company.

Names of Parts, Route Locking Circuits with Electrical Time Circuit Breaker; Fig. 2903.

A *Track Relay*
B *Control Relay*
C *Electric Lock*
D *Floor Push*
E *Main Battery*
F *Track Battery*
G *Operating Terminal on Time Circuit Breaker*
J *Wire*
K *Operating Terminal in Time Circuit Breaker*
L *Circuit Breaker Operated by Signal Levers*
M *Contact*
N *Contact*
O *Contact Arm*
P *Contact Arm*
R *Track Relay Lead*
S *Track Relay Lead*
T *Wire*
W *Wire*
X *Wire*

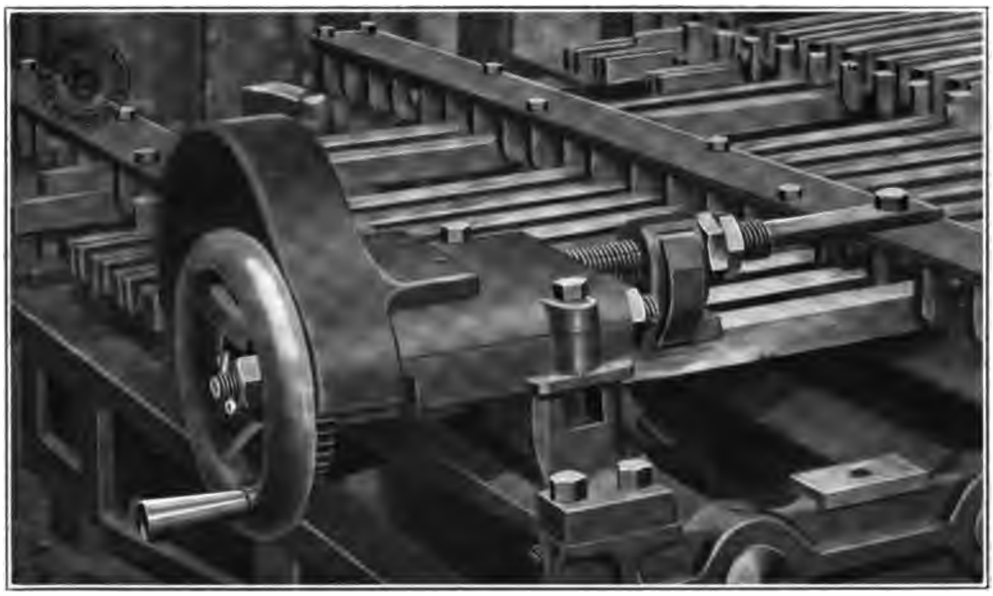


Fig. 2904. Model 2 Mechanical Hand Release Applied to a Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.

do with the tappet on which the lock acts when the screw release is reversed, thereby holding the route locked until the release has been returned to its normal position.

In Fig. 2903 is shown an application of an electrical time circuit breaker (Figs. 2899-2902) used to introduce a time element in releasing the route locking of an interlocking plant. The time circuit breaker is an electrical device which will make or break one or more circuits a predetermined number of minutes after it has been put in action. Reversal of any one of the signal levers opens circuit breaker L and de-energizes relay B. This opens the circuit of lock C which passes from battery E through contact of B, wire J, contact of A, to terminal O, through contact of time circuit breaker, terminal M, floor push D, lock C to battery. Relay B is a stick relay and cannot again pick up until relay A is de-energized, owing to the presence of a train on the track circuit with all signal levers normal or until the time release has acted. When relay A is de-energized it restores B through a back point but keeps the circuit for lock C open. Relay A is also a stick relay and cannot pick up until B is energized. If the wrong route has been lined up and it is necessary to restore the functions to normal without being released by a train, the signalman presses the strap-key which puts the time circuit breaker in operation. After the proper interval of time contacts N and P are brought together and relay B is energized thereby, but at the same time contacts M and O are opened, thereby keeping lock C de-energized until the time circuit breaker has ceased to act.

With the electric locks on the switch levers the operation of the emergency release, Figs. 2904-2906, made by the Union Switch & Signal Company, is as follows:

The signal lever being normal, the handle is turned to lock the signal lever normal mechanically and release the electric lock on the switch lever mechanically. The switch lever can now be reversed. Reversal of the direction of rotation of the handle restores the device to its normal position, thus releasing the signal lever from this special mechanical locking. If the electric locks are on the signal levers the switch levers are locked during an operation. The time required for an operation depends upon the apparatus and adjustment provided. The slow speed apparatus con-

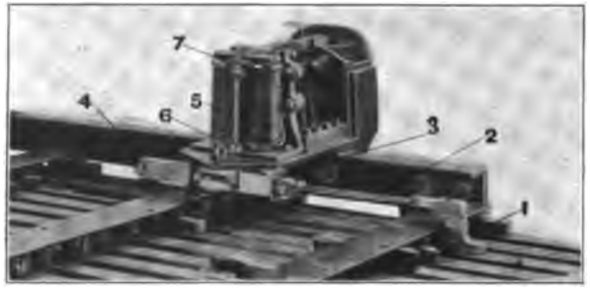
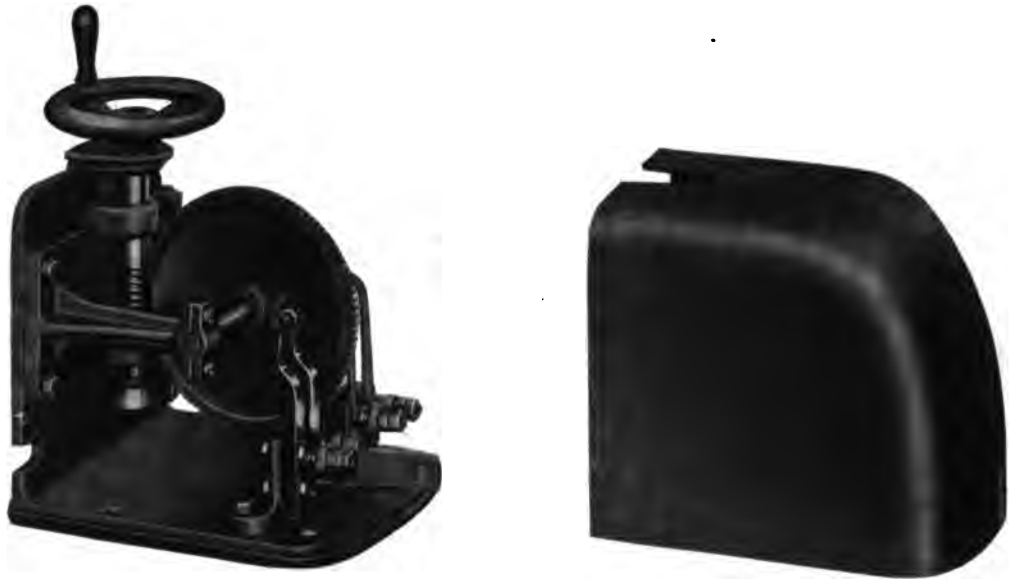


Fig. 2905. Releasing Attachment for Model 2 Electric Lock Applied to a Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.

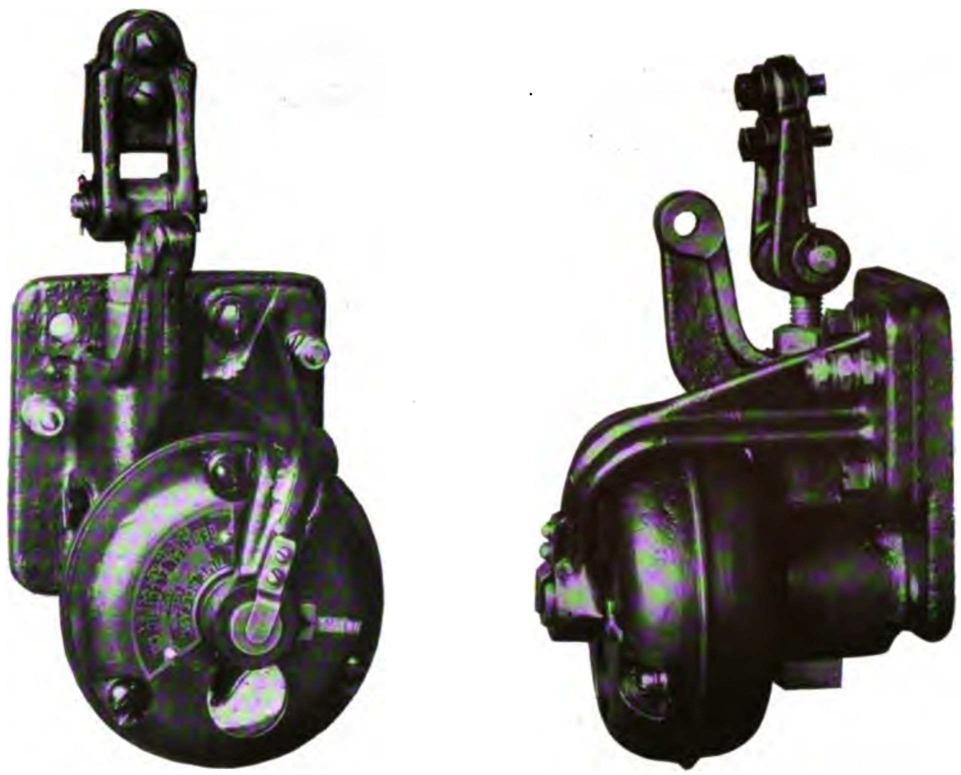


Figs. 2907-2908. Wall Type, Hand Screw Release Circuit Controller. The Union Switch & Signal Company.

Fig. 2906. Model 2 Electric and Release Applied to a Saxby & Farmer Interlocking Machine. The Union Switch & Signal Company.

Names of Parts, Releasing Attachment for Model 3 Electric Lock Applied to a Saxby & Farmer Interlocking Machine; Fig. 2905.

1 *Lug*
2 *Adjustable Link*
3 *Motion Plate Guide*
4 *Motion Plate*
5 *Brass Operating Rod*
6 *Brass Bushing*
7 *Spring*



Figs. 2909-2910. Time Release for Interlocking Machine. General Electric Company.

sists of gearing, in the circular case, turned by the wheel and handle to drive a special locking bar as shown in Fig. 2905. Fig. 2905 represents the electric lock and the special releasing arrangement underneath. The locking bar is connected by a lug 1, and link 2, to the slotted bar 4, engaging with the rod 5, in such a manner as to operate mechanically the armature of the electric lock, raise the locking dog and release the lock. Fig. 2905 shows the lock released and the locking bar in its full reversed position. This locking bar in any other than its normal position mechanically locks the signal lever normal through the cross locking.

The devices in Fig. 2906, made by the Union Switch & Signal Company, perform the same function electrically as the releases already described, by closing normally open circuit controllers, in the rectangular boxes, shown with covers removed, thereby affecting the lock circuit. To insure its return to the normal position other circuit controllers, normally closed, affecting the control or locking of the signals are opened to prevent the clearing of the signals during the operation of the release. This may also be arranged to lock conflicting levers mechanically. The electric lock shown in this illustration is not connected, except electrically, with the hand releases. In this arrangement the hand wheel, through gearing, slowly moves the flat bar leading into the circuit controller box. To this bar is attached a contact plate engaging springs in such a manner as to open and close contacts as described. The circuit controller box is the same as that employed in the electro-pneumatic system for indication boxes at switches.

Figs. 2907-2908 show another type of instrument made by the Union Switch & Signal Company, designed to accomplish the same result as those above described by a semi-electrical method. It is used principally with power interlockings where it may be placed at any desired point in the tower. A gear wheel is driven by a worm gear on a shaft to which is connected the hand wheel. The movement of the gear wheel can be arranged to open or close one or more contacts as desired to affect the control of signals and locks and require the return to its normal position. Provision is made for controlling the high voltage currents employed in electric interlocking by having contacts of a slightly different construction. A brake is also provided so as to prevent false movements from affecting the contacts. An indicator can be furnished to show the position of the apparatus, while the cams driven by the gear wheel control the contacts in such a manner as to provide for always turning the handle in the same direction for restoring as for setting, giving, if desired, a long time interval for releasing the locks and a very short interval for returning to the normal position.

The time release made by the General Electric Company, shown in Figs. 2909-2910, is designed for direct connection to an interlocking machine, the connection being made either directly to the tappet, by means of the insulated yoke and bolts shown in the illustrations, or to the tail lever by means of a gain-stroke lever, the fulcrum for which is the lug which is seen projecting from the frame of the apparatus. The circuit closing device consists of a glass tube, containing mercury, hermetically sealed and provided with contact terminals. This glass tube is held in a circular case, which is turned through the required angle by means of a rack and pinion. The construction is such that when the tube is turned in a given direction, mercury flows from one chamber to another through a small orifice. The reverse motion returns the mercury through a large orifice. When the latch of the machine is raised, the mercury is thrown away from the contacts, opening the circuit. When the lever and latch are placed normal the mercury flows through the small orifice and, after a predetermined time, completes the circuit between the terminals inside the glass, thus closing the lock circuit. These devices are also arranged with double circuits to take the place of the mechanical screw-release. As so arranged, contacts in one chamber close the stick relay circuit immediately and, upon reversal, the lever lock circuit is closed after one minute or other specified time.

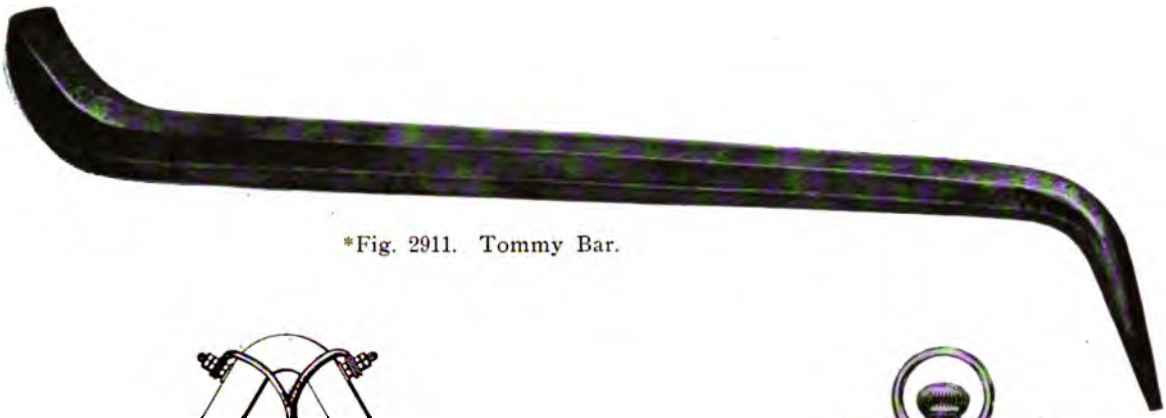


*Fig. 2911. Tommy Bar.

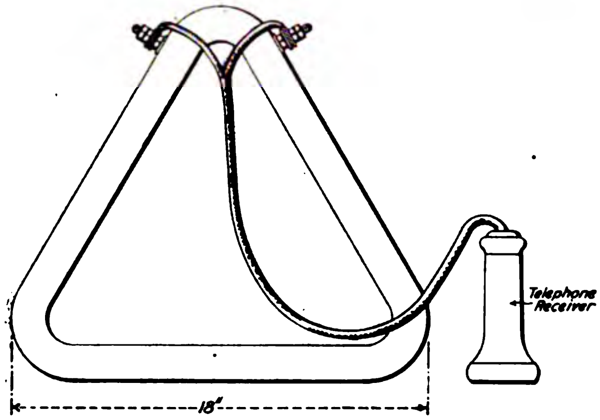
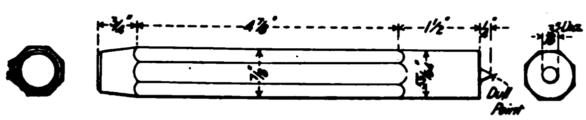


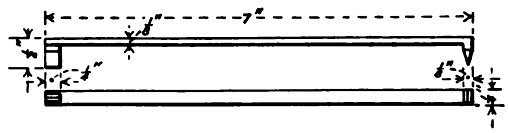
Fig. 2912. Exploring Coil for Alternating Current Track Circuits. General Railway Signal Company.

Fig. 2913. Pocket Voltmeter. Eldridge Electric Manufacturing Company.

Figs. 2914-2915. Magneto Testing Set with Telephone. Central Electric Company.



*Figs. 2916-2918. Lock Rod Center Punch.



*Figs. 2919-2920. Special Screw Driver for Binding Posts, etc.

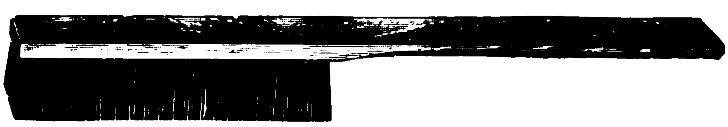


*Fig. 2921. Battery Cleaning Brush.

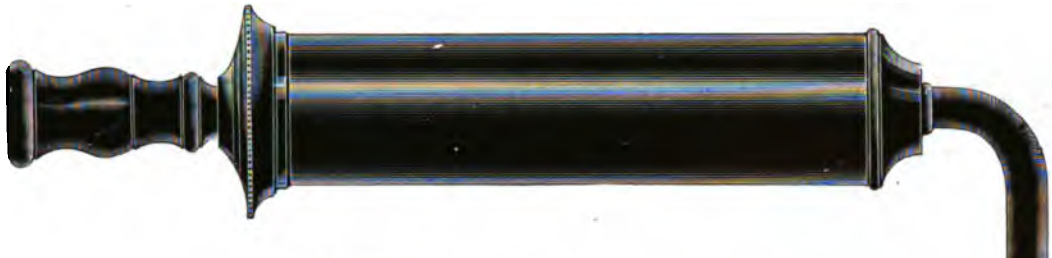
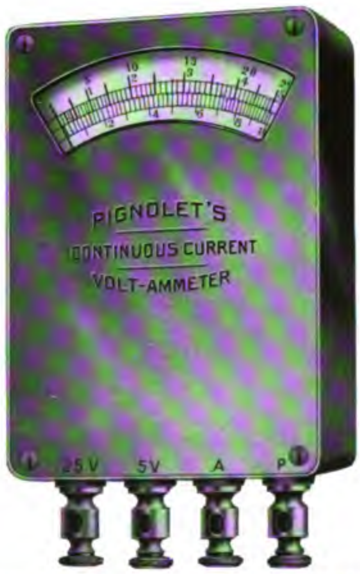


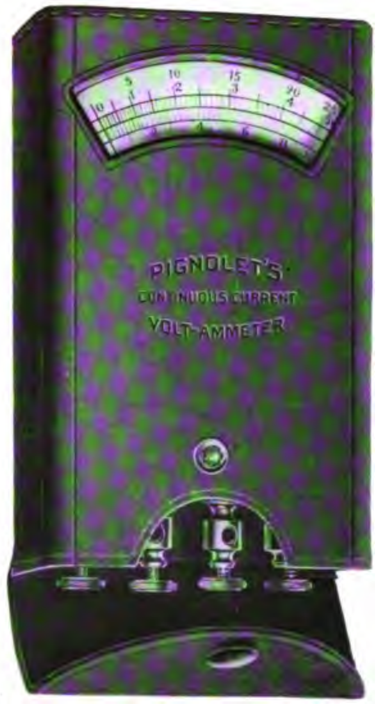
*Fig. 2922. Battery Syringe.

*Fig. 2923. Gravity Battery Cleaning Knife.

Fig. 2924. Counter for Signals. Veeder Manufacturing Company. See Fig. 1794 for Application.

*Figs. 2927-2928. Storage Battery Hydrometers.





Figs. 2925-2926. Pignolet Voltmeter and Volt-Ammeter.

Fig. 2929. Portable Direct Current Volt-Ammeter. Western Electrical Instrument Company.

Fig. 2930. Portable Alternating Current Voltmeter. Western Electrical Instrument Company.

Fig. 2931. Switchboard Voltmeter.

Fig. 2933. Edgewise Switchboard Voltmeter.

Fig. 2932. Switchboard Ammeter.

Fig. 2934. Portable Direct Current Voltmeter.

Figs. 2935-2937. Portable Mill-Ammeter.

Figs. 2938-2941. Multipliers for Portable Voltmeters.

Figs. 2942-2945. Portable Alloy Shunts.

Figs. 2931-2945. Electrical Measuring Instruments. Western Electrical Instrument Company.

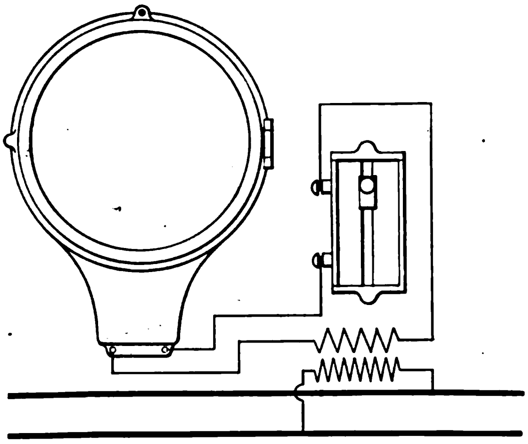


Fig. 2946. Circuit Diagram, Recording Voltmeter with Potential Transformer for Alternating Current.

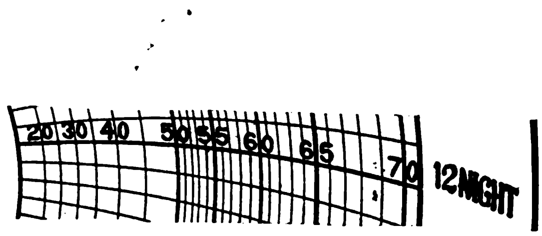


Fig. 2947. Section of Voltmeter Chart.

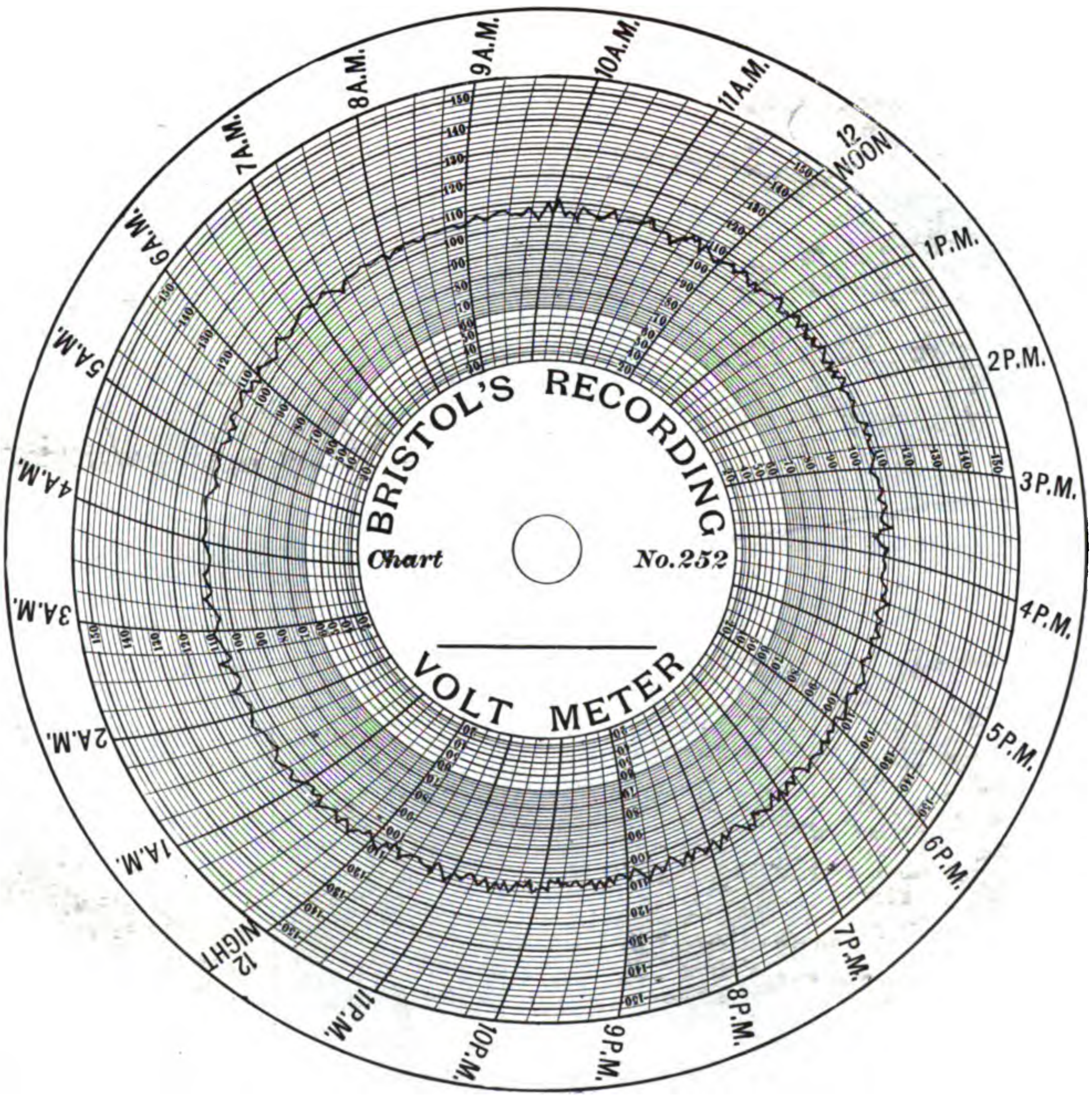


Fig. 2948. Voltmeter Chart Showing Record.

Figs. 2946-2948. Recording Instruments. Bristol Company.

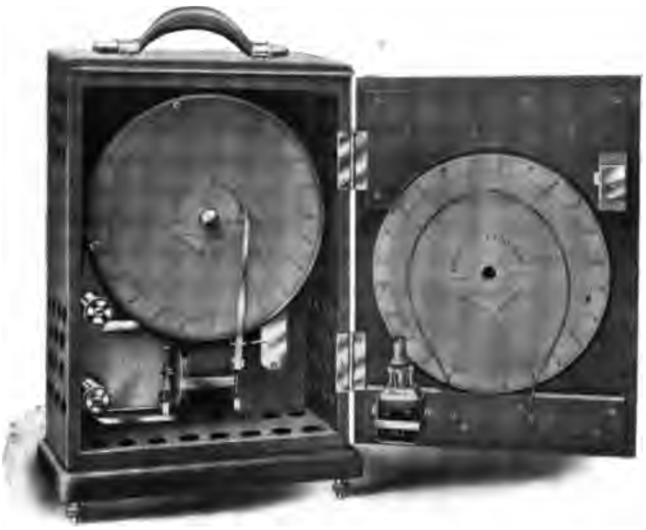


Fig. 2949. Portable Recording Ammeter.

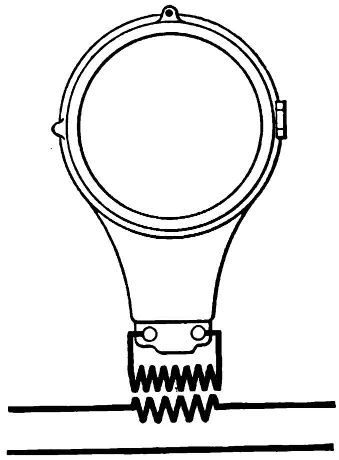


Fig. 2950. Circuit Diagram; Recording Ammeter with Current Transformer for Alternating Current.

Fig. 2951. Recording Voltmeter, Front View.

Fig. 2952. Recording Voltmeter, Rear View, Cover Removed.

Fig. 2953. Recording Pressure Gage, Rear View, Cover Removed.

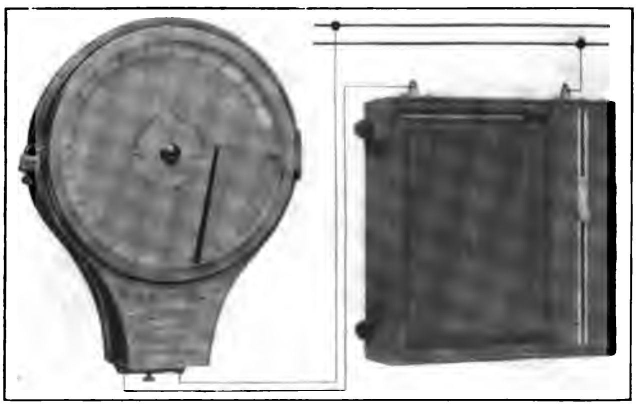


Fig. 2954. Recording Voltmeter and Resistance Box Showing Connections.

Figs. 2949-2954. Recording Instruments. Bristol Company.

Fig. 2955. Recording Pressure Gage in Case. Bristol Company.

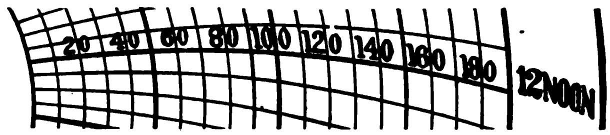


Fig. 2956. Section of Pressure Gage Chart. Bristol Company.

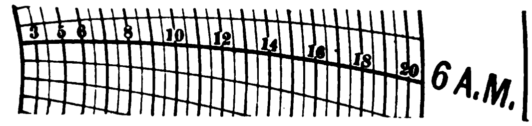


Fig. 2957. Section of Ammeter Chart. Bristol Company.

Fig. 2958. Hydrometer in Syringe. Electric Storage Battery Company.

Fig. 2959. Differential Hydrometer. Electric Storage Battery Company.

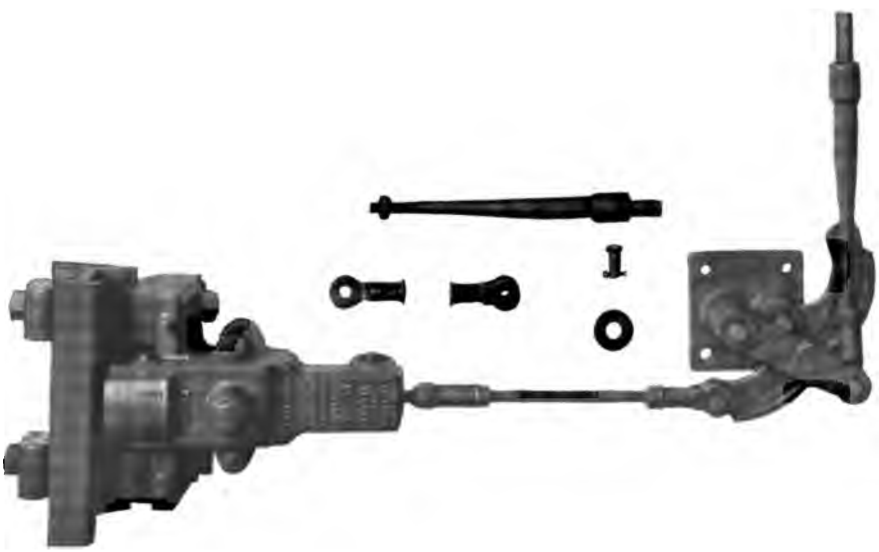
Fig. 2960. Torpedo Placer with Cover Removed.

Fig. 2961. One Pair of Torpedoes on Rail; Two, Detached, Lying on Top of Cover.

Fig. 2962. Electric Motor for Torpedo Placer; Turned Out of Case, Bottom Side up for Inspection.

Fig. 2963. Torpedo Placer and Guard Rail.

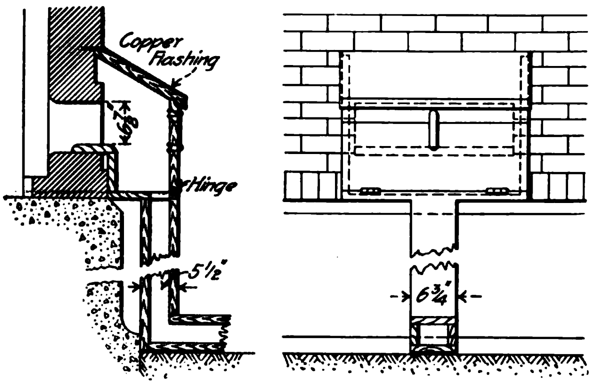
Figs. 2960-2963. Zorge Torpedo Placer.



Figs. 2964-2969. Torpedo Placer. The Union Switch & Signal Company.

Fig. 2970. Typical Interlocking Cabin. Boston Elevated.

Fig. 2971. Brick Interlocking Tower and Power House at Marble Hill. Electric Zone, New York Central & Hudson River.



Figs. 2972-2973. Details of Trunking Leadout.

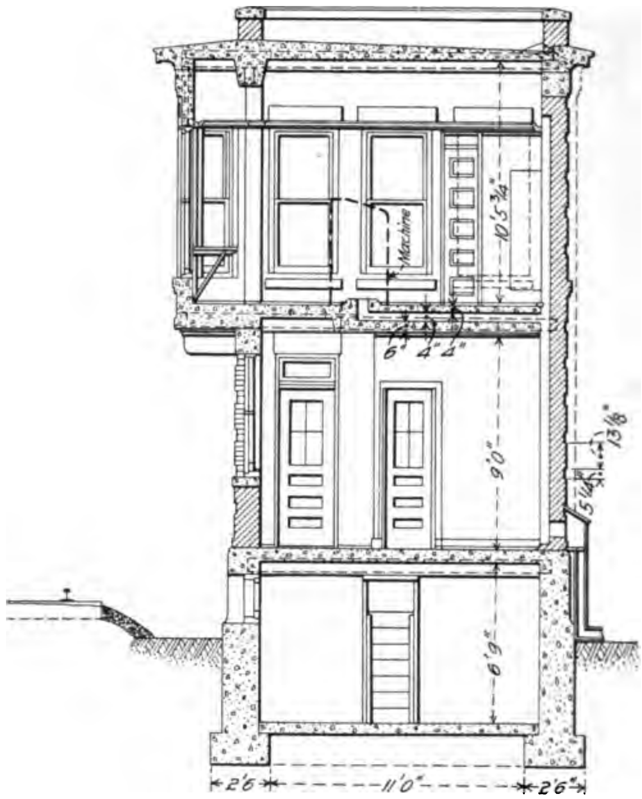


Fig. 2974. Transverse Section.

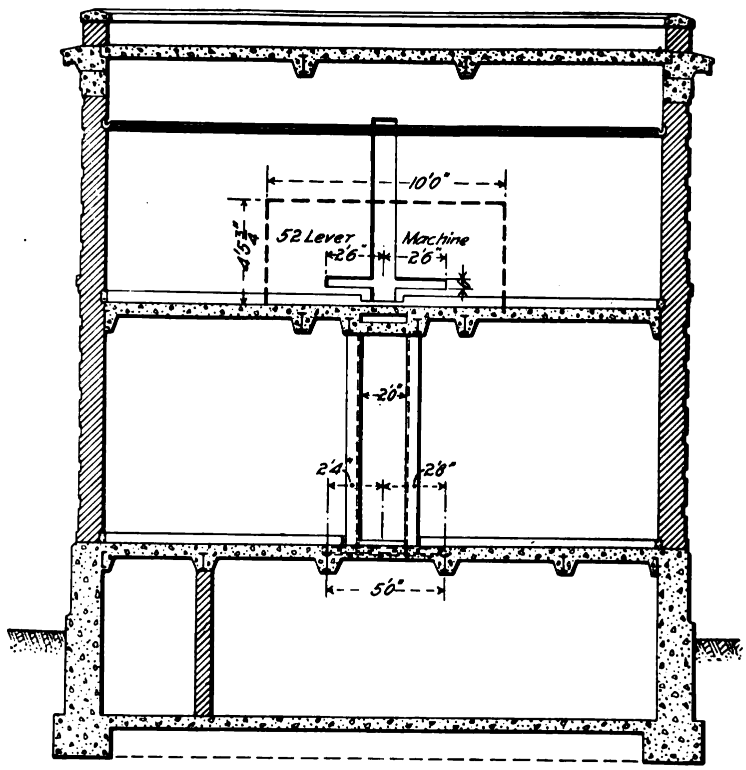


Fig. 2975. Longitudinal Section.

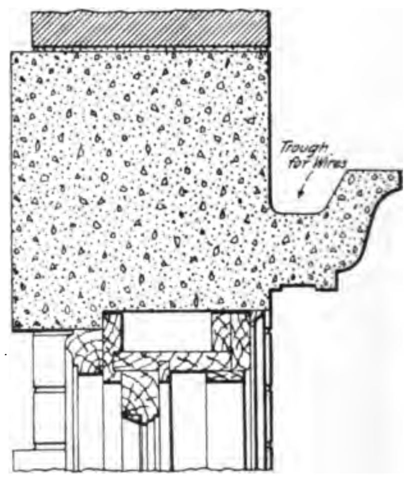


Fig. 2976. Section of Wall Above **Windows** Showing Trough for Wires.

Figs. 2972-2976. Details of Interlocking Tower at Marble Hill. Electric Zone, New York Central & Hudson River. See Fig. 2971.

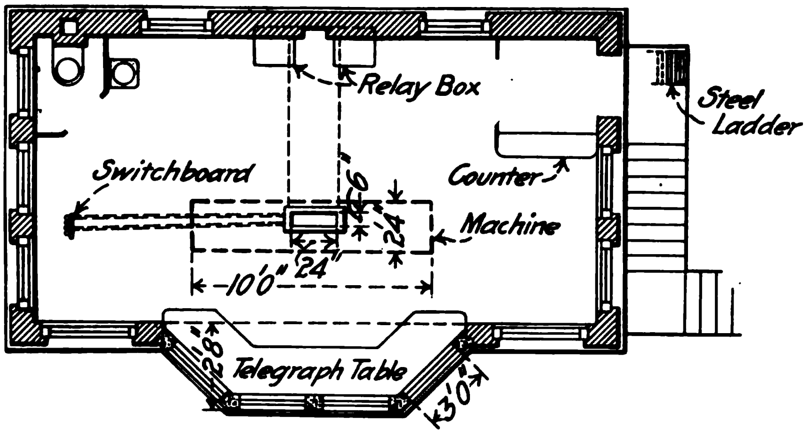


Fig. 2977. Plan of Upper Floor.

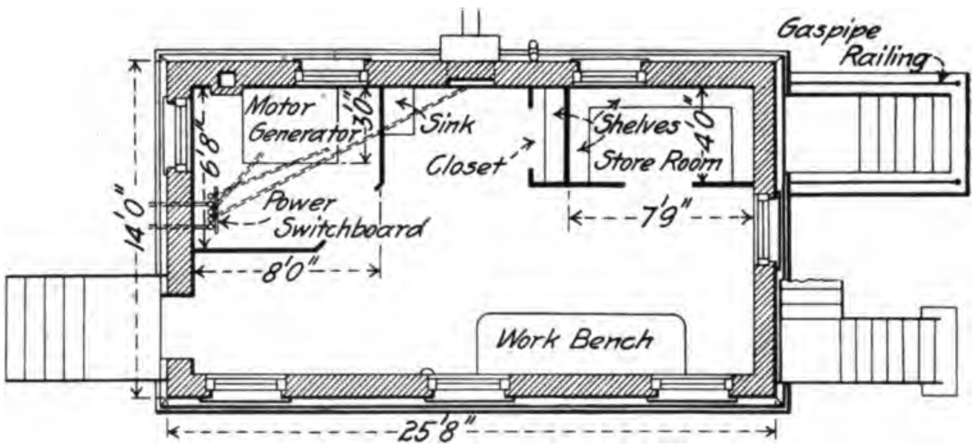


Fig. 2978. Plan of First Floor.

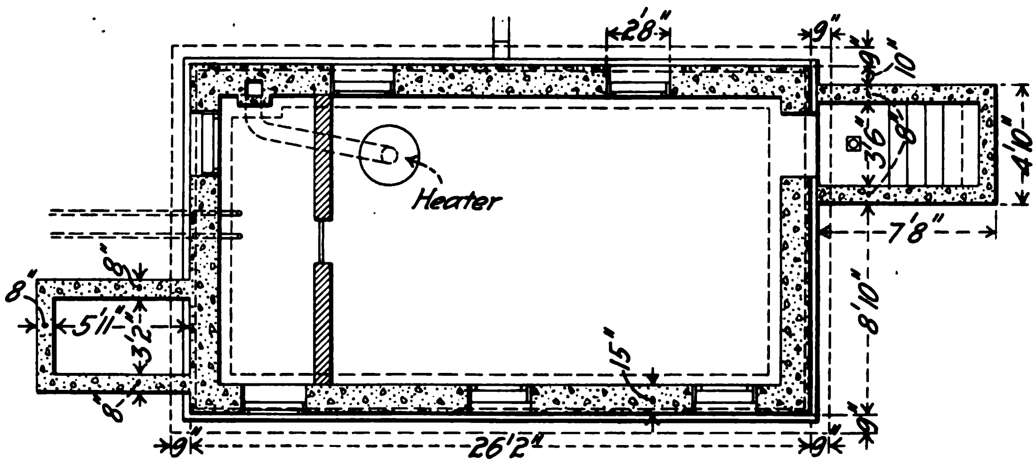
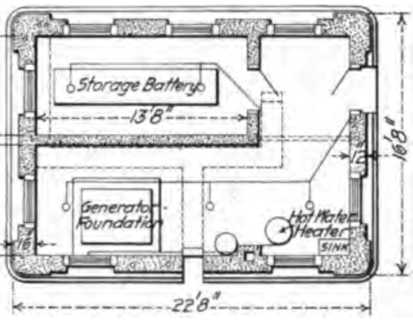
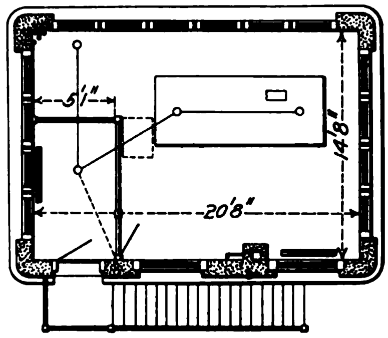


Fig. 2979. Plan of Basement.

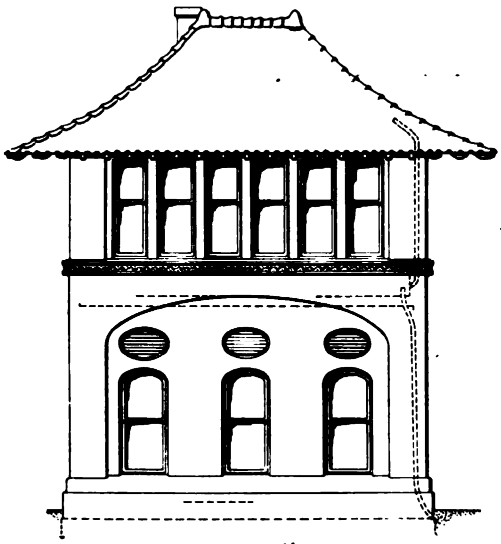
Figs. 2977-2979. Details of Interlocking Tower at Marble Hill. Electric Zone, New York Central & Hudson River. See Fig. 2971.



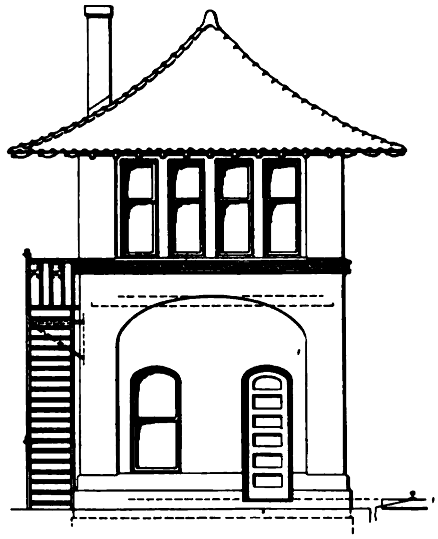
First Floor Plan.



Second Floor Plan.

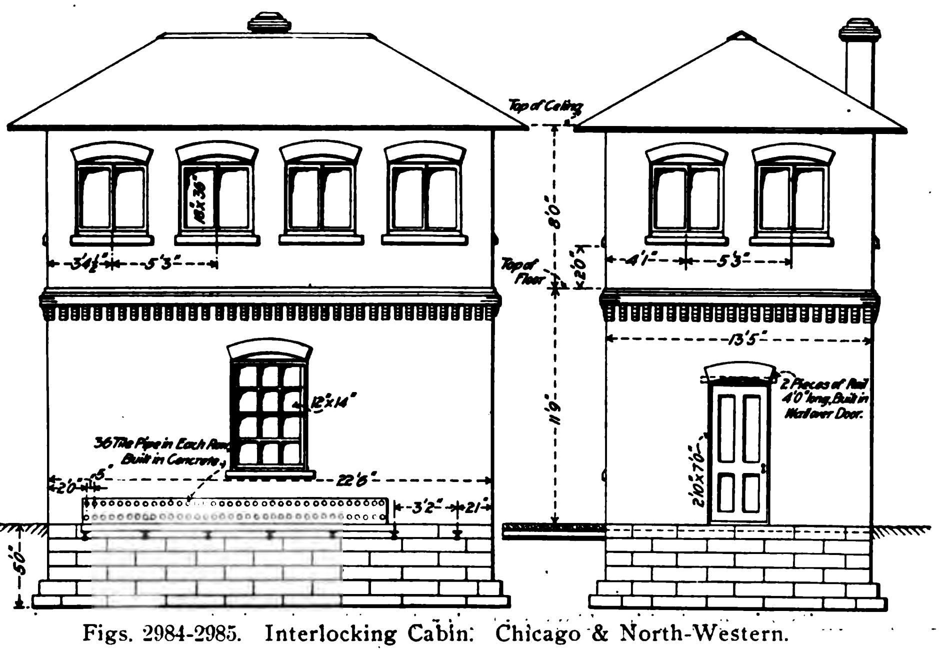


Front Elevation.

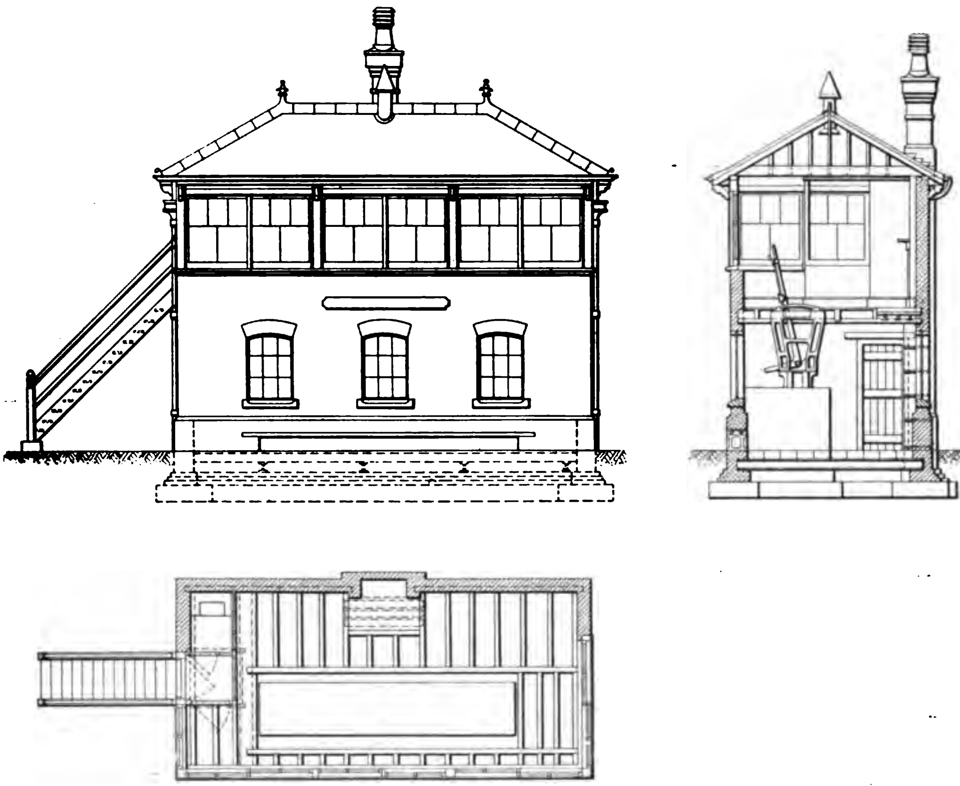


End Elevation.

Figs. 2980-2983. Reinforced Concrete Interlocking Cabin for Union Electric Interlocking Plant. New York, New Haven & Hartford.



Figs. 2984-2985. Interlocking Cabin: Chicago & North-Western.



Figs. 2986-2988. Interlocking Cabin or Signal Box. Great Western Railway of England.

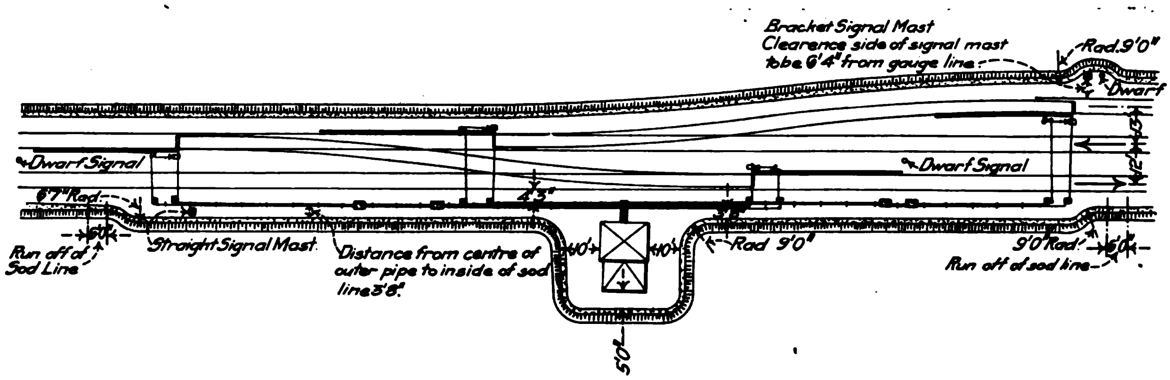
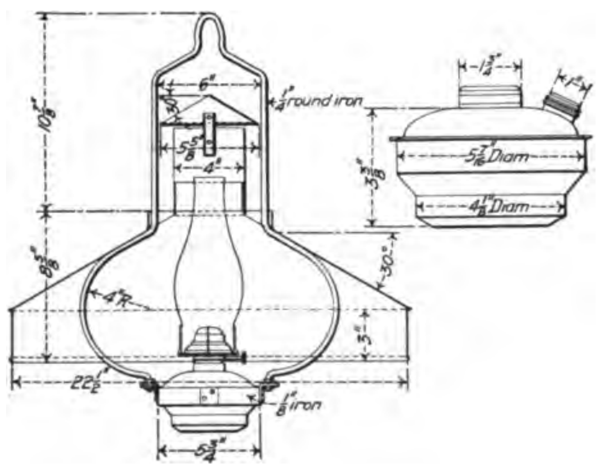
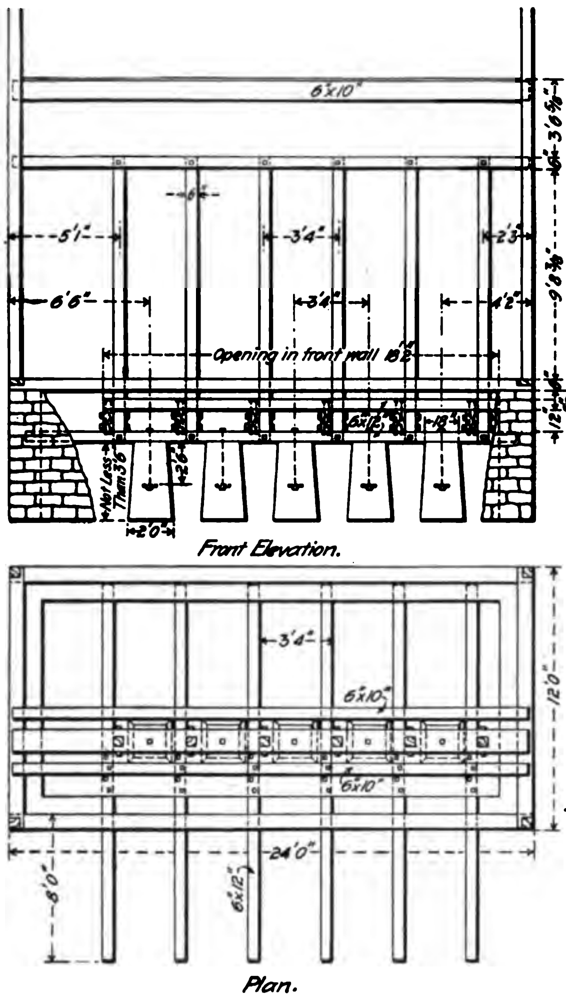


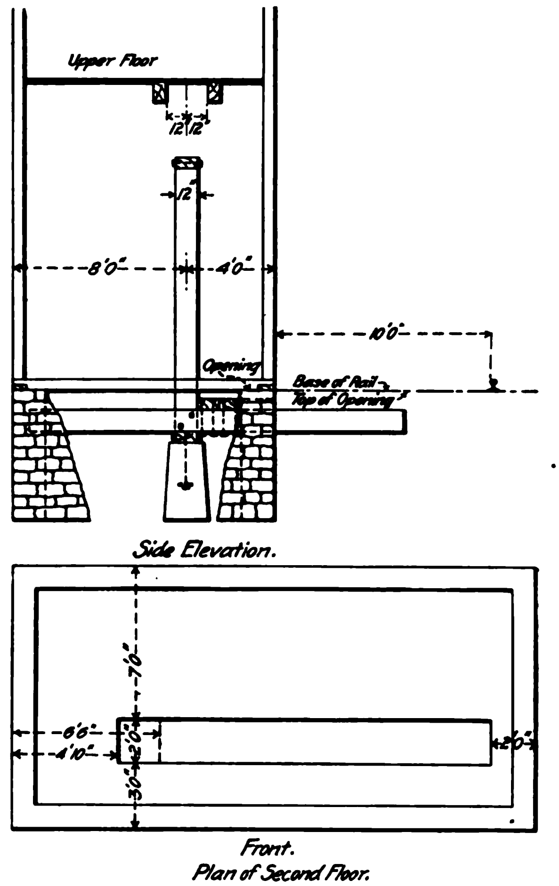
Fig. 2989. Typical Layout for Interlocking Plant on a Fill, Showing Pipe Lines, Cabin, Cranks, Compensators, Signal Locations, Detector Bars and Cross Leads. New York Central & Hudson River.

Fig. 2990. Porcelain Electric Lamp Socket. Central Electric Company.

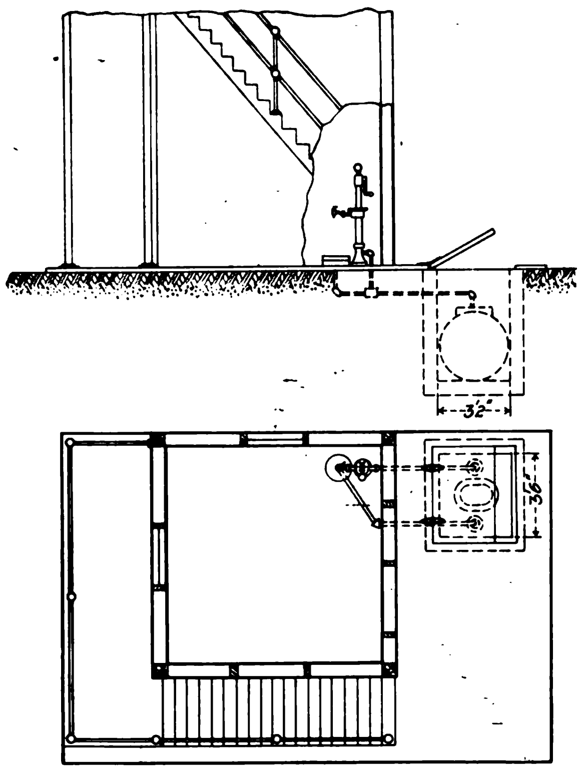


Figs. 2991-2992. Standard Tower Lamp. New York Central & Hudson River.

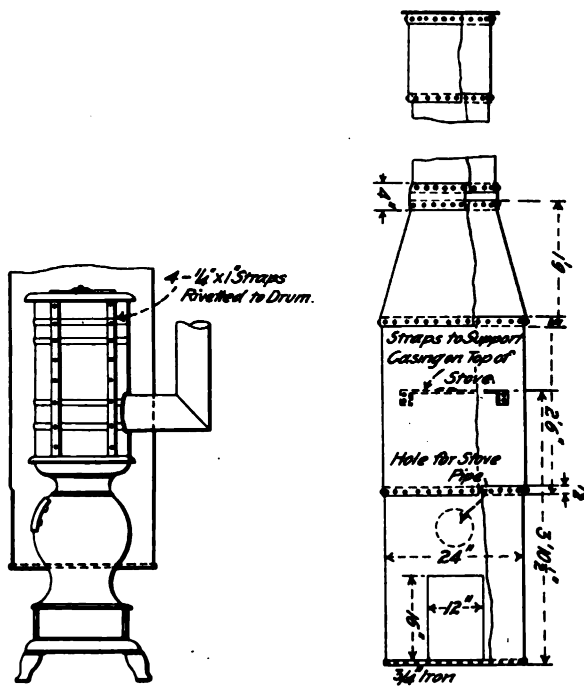




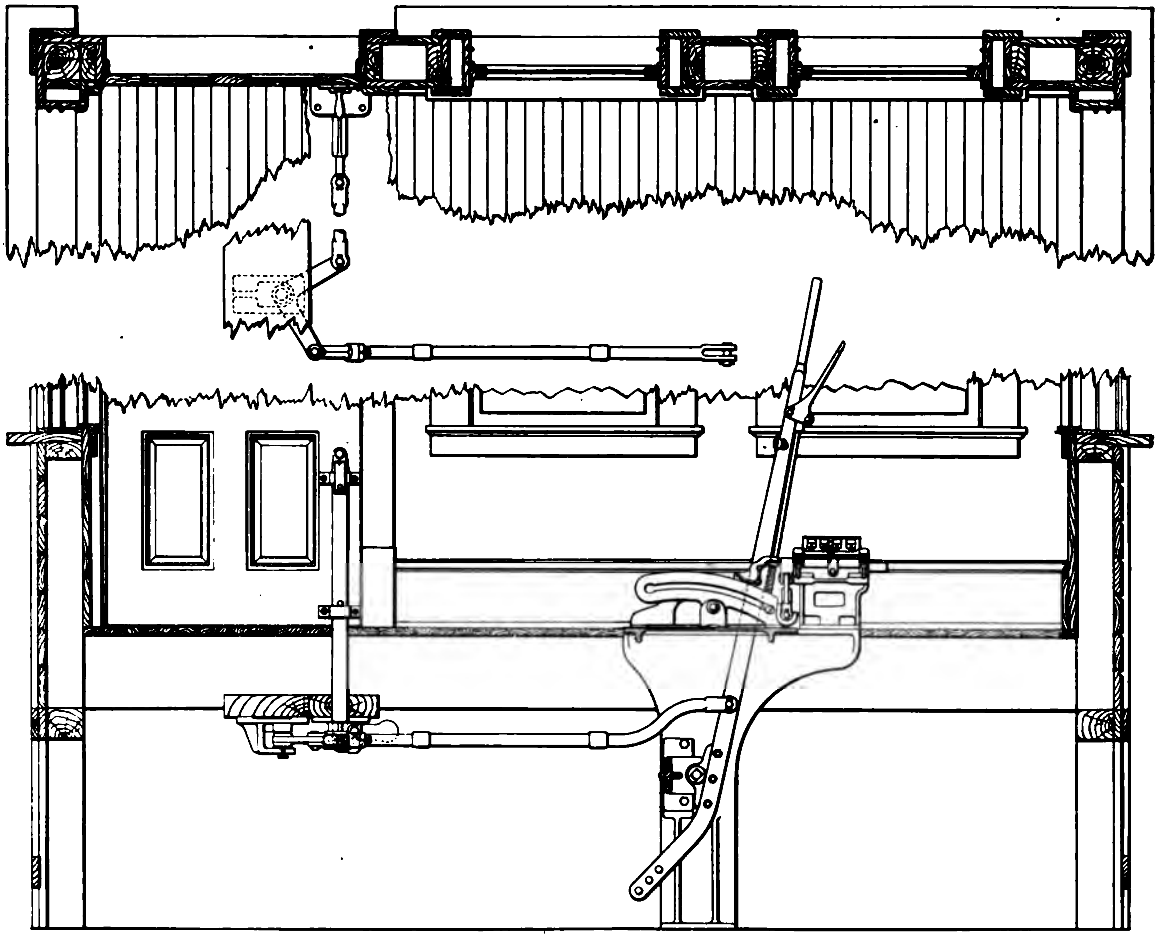
Figs. 2993-2996. Interlocking Cabin Foundation and Framing for Mechanical Interlocking Machine. Baltimore & Ohio.



Figs. 2997-2998. Location of Oil Tank and Pump at Interlocking Tower. New York Central & Hudson River.

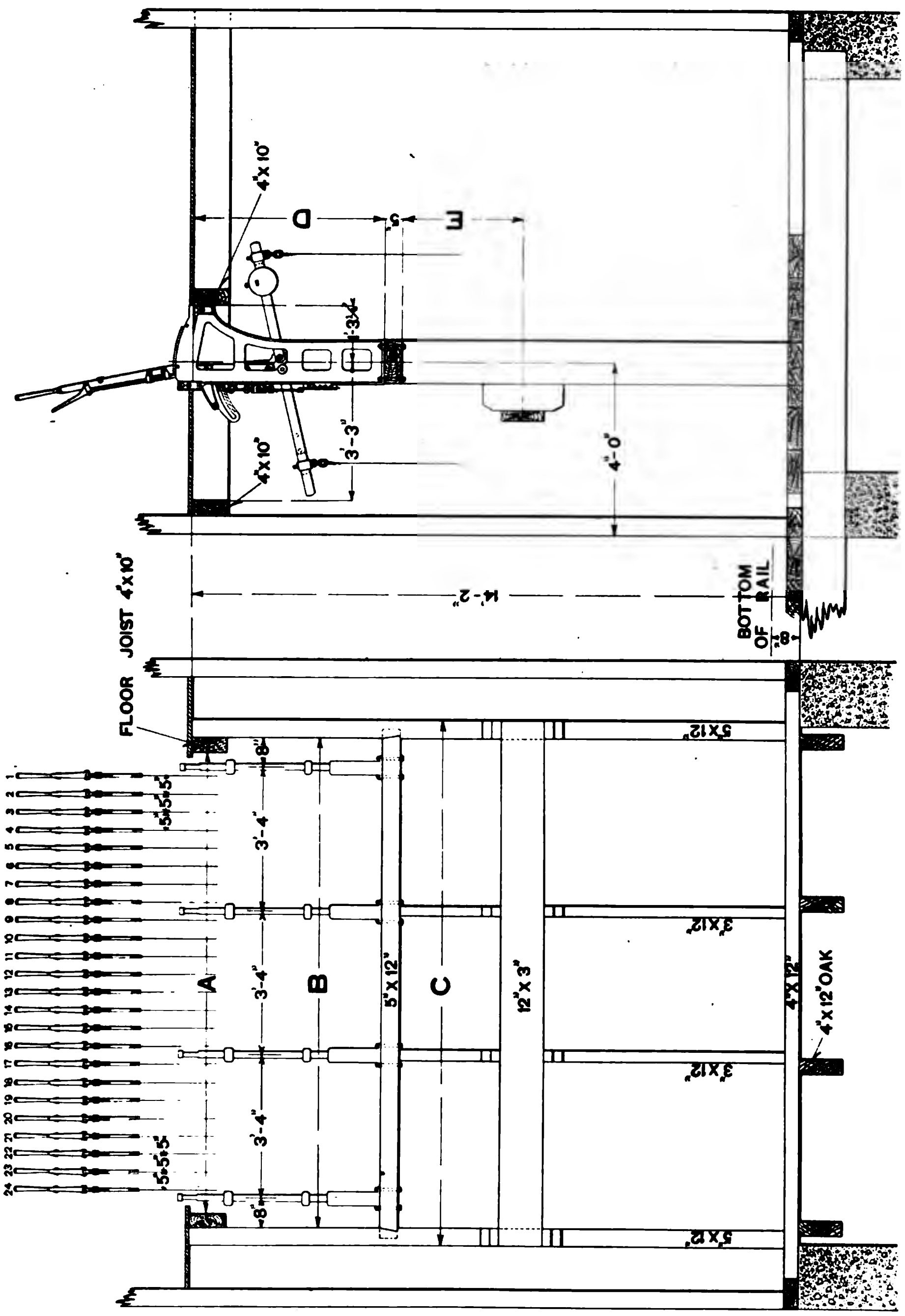


Figs. 2999-3000. Tower Stove and Details of Casing. Chicago, Milwaukee & St. Paul.

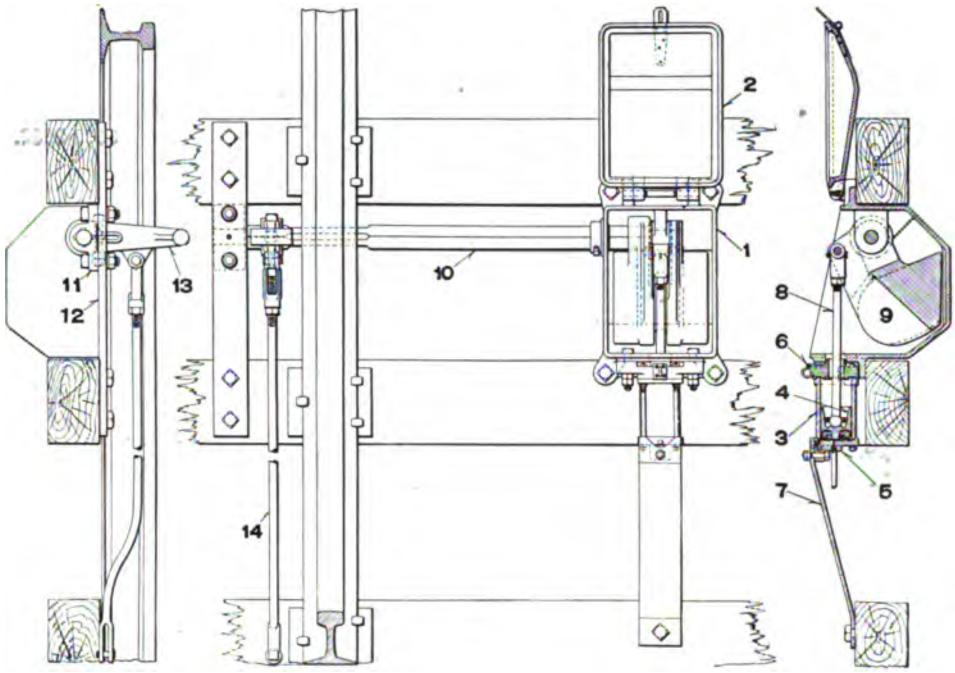


*Figs. 3001-3002. Locking Device for Cabin Door.

Fig. 3003. Brick and Concrete Interlocking Cabin for Electro-Pneumatic Interlocking Plant at Hoboken. Delaware, Lackawanna & Western.



*Figs. 3004-3005. Cabin Framing for Johnson Interlocking Machine.



Figs. 3006-3008. Electro-Pneumatic, Automatic Train Stop. The Union Switch & Signal Company.

Names of Parts, Electro-Pneumatic Train Stop; Figs. 3006-3008.

1	*Counterweight Box*	6	*Back Cylinder Head*	11	*Shaft Bearing*
2	*Counterweight Box Cover*	7	*Cylinder Guard*	12	*Bearing Plate*
3	*Cylinder*	8	*Piston Rod*	13	*Stop Arm*
4	*Piston*	9	*Counterweight*	14	*Connecting Rod*
5	*Front Cylinder Head*	10	*Shaft*		

Fig. 3009. Electro-Pneumatic, Automatic Train Stop. The Union Switch & Signal Company.

Fig. 3010. Automatic Train Stop. Boston Elevated.

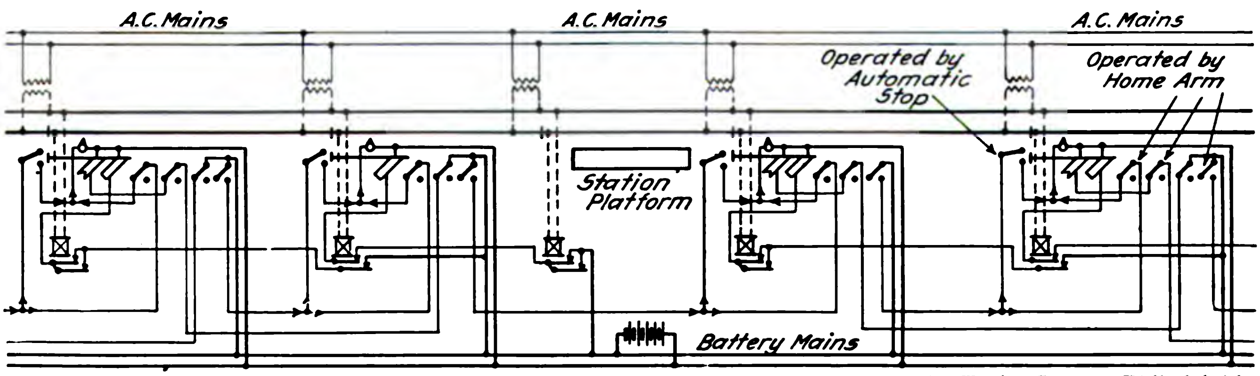
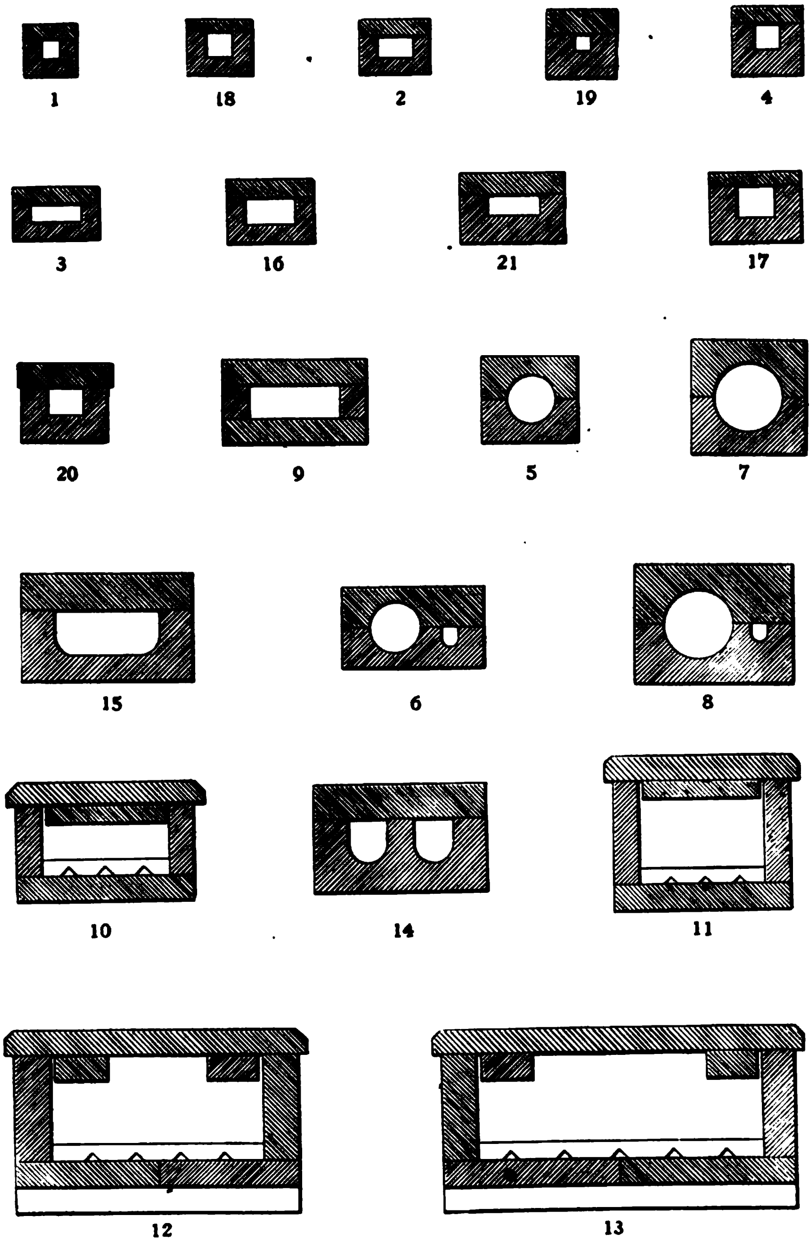


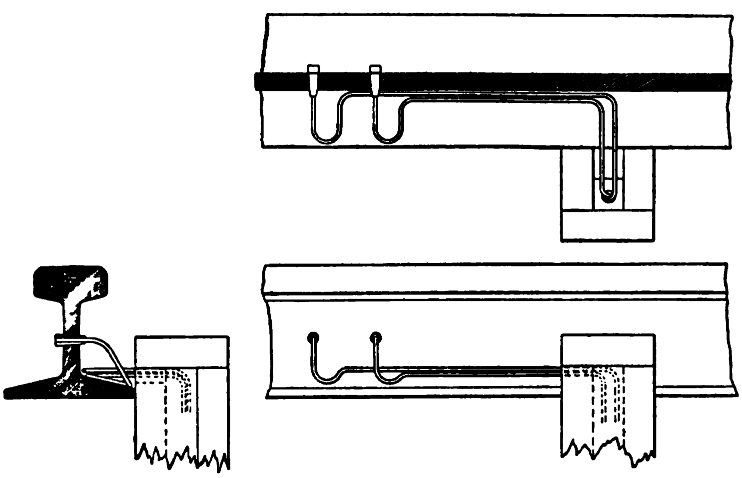
Fig. 3011. Typical Circuits for Control of Automatic Block Signals and Automatic Train Stops. Philadelphia Rapid Transit Company. The Union Switch & Signal Company.



*Figs. 3012-3032. Types of Trunking and Capping.

Names of Parts, Trunking; Figs. 3012-3032.

1 *Grooved Trunking with 1" x 1" Opening*
2 *Grooved Trunking with 1" x 2" Opening*
3 *Grooved Trunking with 1" x 3" Opening*
4 *Grooved Trunking with 1½" x 1½" Opening*
5 *Grooved Trunking with 2⅞" Opening*
6 *Grooved Trunking with 2⅞" and 1" Opening*
7 *Grooved Trunking with 4" Opening*
8 *Grooved Trunking with 4" and 1" Opening*
9 *Boxed Trunking with 2" x 5" Opening*
10 *Boxed Trunking with 2" x 7" Opening*
11 *Boxed Trunking with 4" x 7" Opening*
12 *Boxed Trunking with 5" x 12" Opening*
13 *Boxed Trunking with 5" x 16" Opening*
14 *Grooved Trunking with 2¼" x 2½" Opening*
15 *Grooved Trunking with 2½" x 6" Opening*
16 *Grooved Trunking with 2" x 3" Opening*
17 *Grooved Trunking with 1¾" x 2⅛" Opening*
18 *Grooved Trunking with 1⅝" x 1⅝" Opening*
19 *Grooved Trunking with 1" x 1" Opening*
20 *Grooved Trunking with 1½" x 2" Opening*
21 *Grooved Trunking with 1" x 3" Opening*



*Figs. 3033-3035. Details of Bootleg and Connection to Rail.

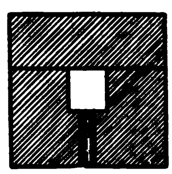


*Fig. 3036. Trunking, with Hole for Drip.

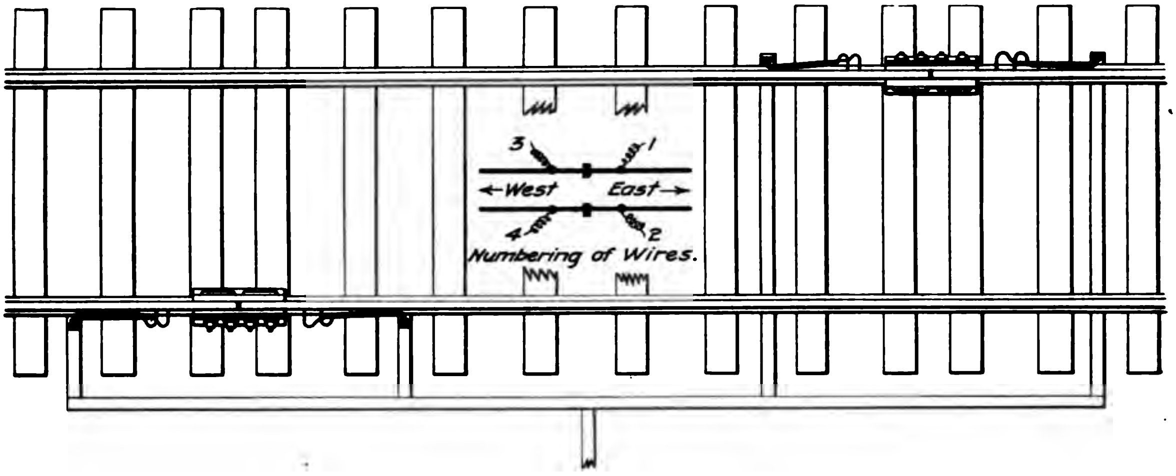
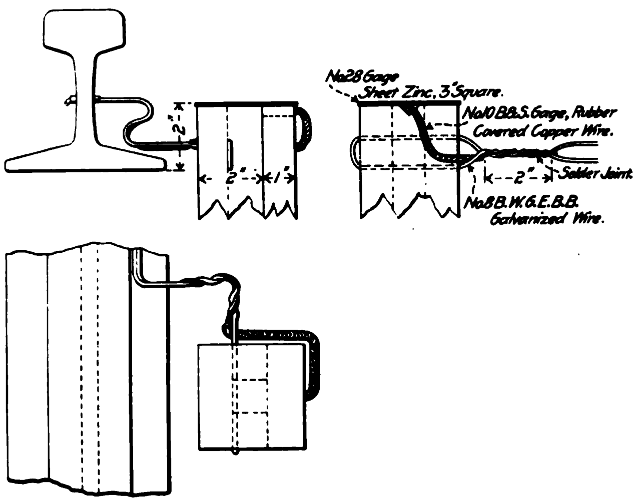
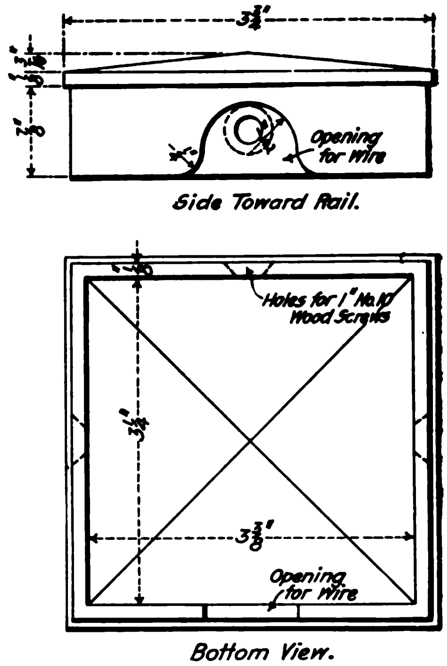


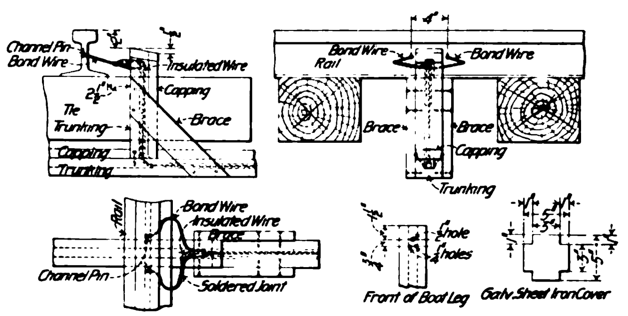
Fig. 3037. Standard Track Wiring and Trunking Run at Signal Location or Cut Section. Southern Pacific-Union Pacific.



Figs. 3038-3040. Bootleg and Wire Connection to Rail. Union Pacific.



Figs. 3041-3042. Malleable Iron Bootleg Cap. Long Island Railroad. T. George Stiles Company.



Figs. 3043-3047. Bootleg and Wire Connection to Rail. Baltimore & Ohio.

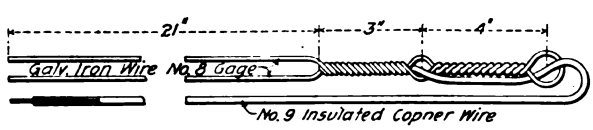
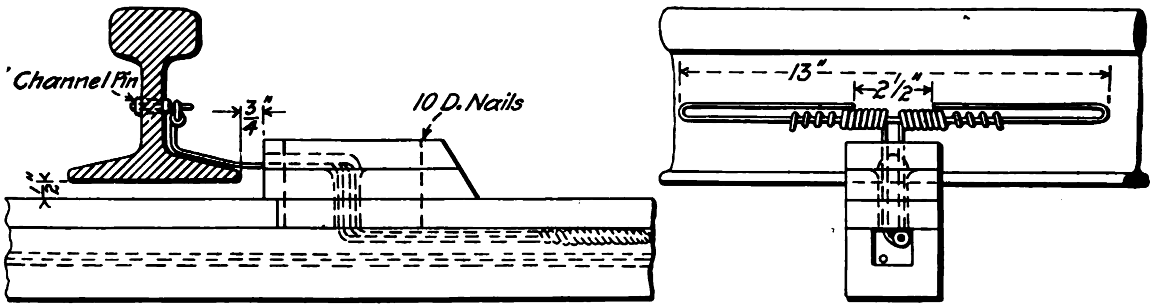
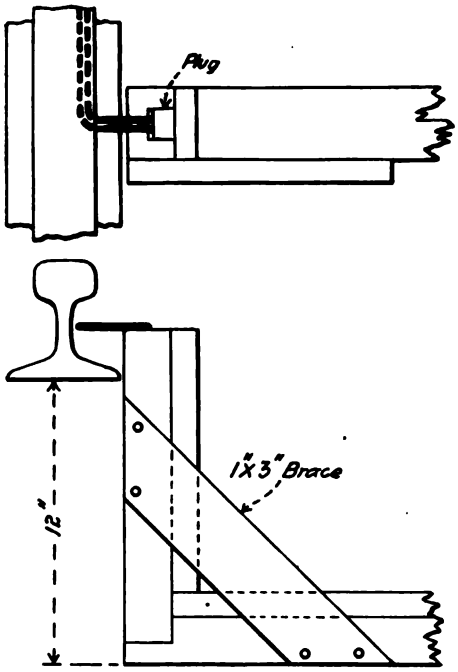


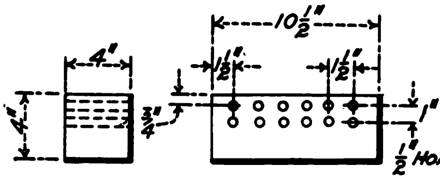
Fig. 3048. Detail of Wire Bootleg. Michigan Central.

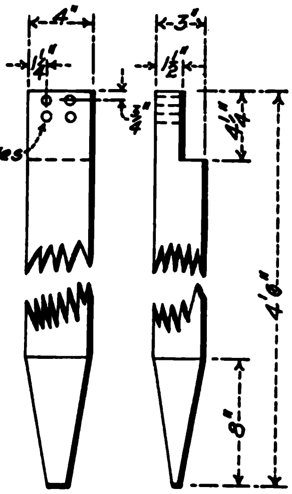


Figs. 3049-3050. Standard Bootleg and Wire Connection to Rail. Illinois Central.

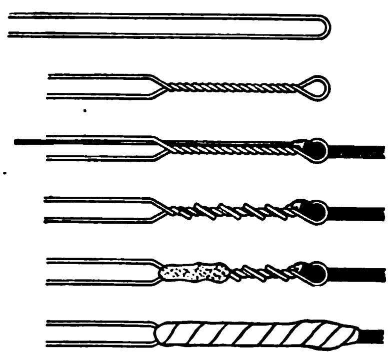


Figs. 3051-3052. Standard Bootleg and Wire Connection to Rail. Southern Pacific.

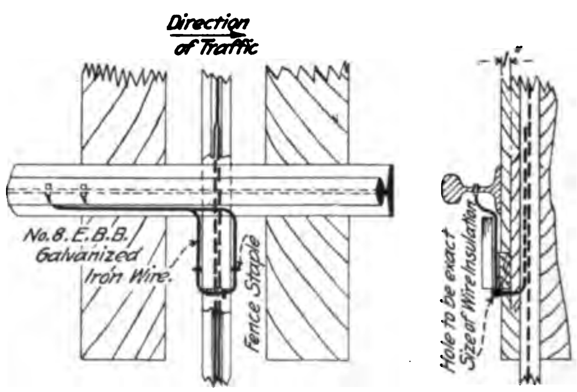




Figs. 3053-3056. Wooden Trunking Stake and Details. Chicago, Milwaukee & St. Paul.



Figs. 3057-3062. Successive Stages in Connecting Iron Bond Wire to Copper Lead to Make Wire Bootleg. The Union Switch & Signal Company.



Figs. 3063-3064. Standard Bootleg and Wire Connection to Rail. New York Central & Hudson River.

The insulation commonly used for wire is some form of rubber compound such as "Kerite," "Okonite," etc., which see under the definitions.

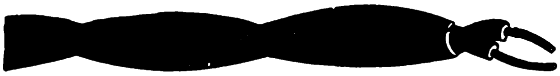


*Fig. 3065. Insulated Twisted Pair.

*Fig. 3066. Insulated Flat Pair.

*Fig. 3067. Solid Copper Conductor; Insulated Plain.

*Fig. 3068. Same as Fig. 3067, with Braid.

*Fig. 3069. Same as Fig. 3067, Taped.

*Fig. 3070. Same as Fig. 3069, with Braid.

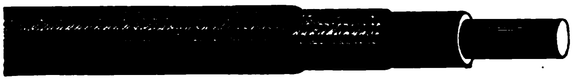


*Fig. 3071. Solid Copper Conductor; Insulated, with Two Braids.

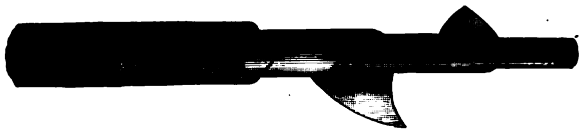


*Fig. 3072. Solid Copper Conductor; Insulated, with Two Tapes and One Braid.

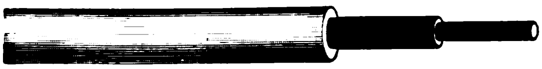


*Fig. 3073. Solid Copper Conductor; Insulated and Lead Covered.

*Fig. 3074. Stranded Copper Conductor; Insulated and Lead Covered.

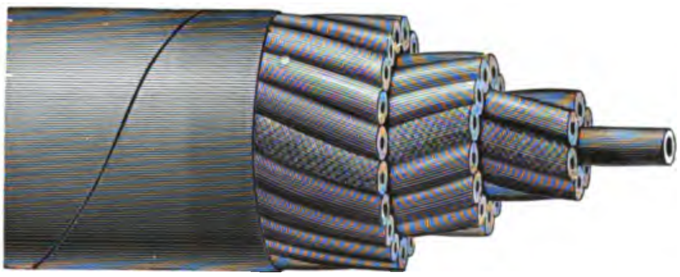


*Fig. 3075. Thirty-seven-Conductor Aerial Cable.

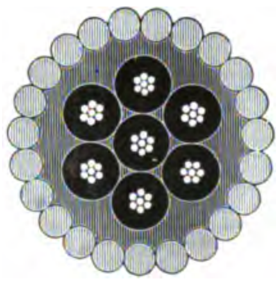


*Fig. 3076. Seven-Conductor Submarine Cable.

*Fig. 3077. Single Conductor Submarine Cable.

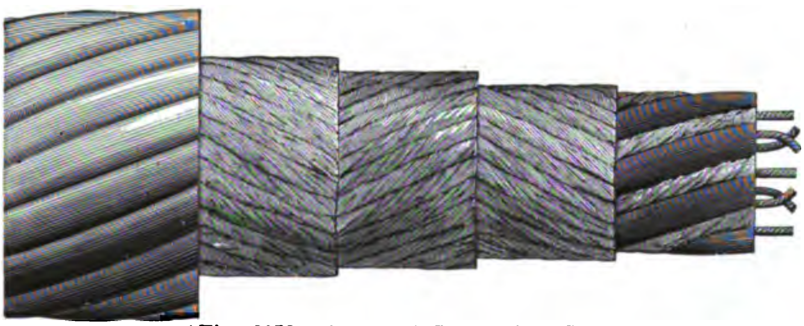


*Fig. 3078. Armored Submarine Cable.

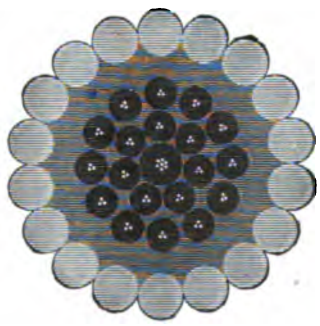


Fig. 3079. Twenty-Conductor Submarine Cable, with Common Return.

*Fig. 3080. Nineteen-Conductor Aerial Cable.

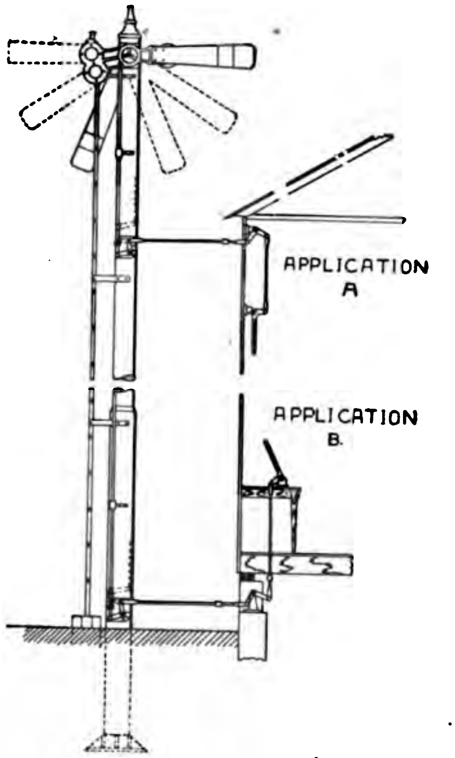
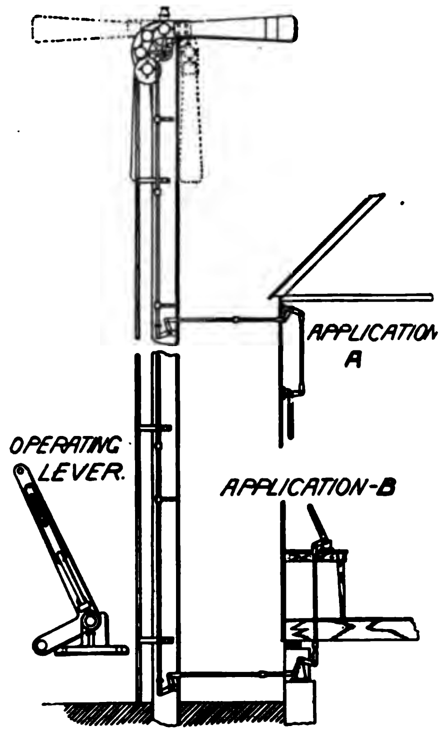
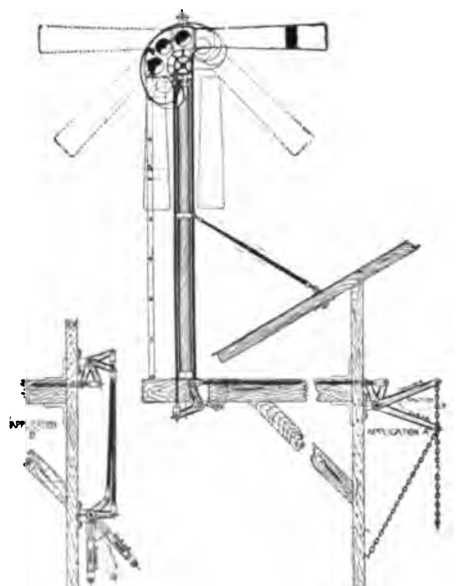


*Fig. 3081. Double, Three-Position, 75-Deg. Train Order Signal; Iron Pipe Post, Pipe Connected.



‡Figs. 3082-3083. Double, Two-Position, 90-Deg. Train Order Signal, Wooden Post, Pipe Connected, with "Universal" Semaphore Casting.



*Figs. 3084-3085. Double, Three-Position, 90-Deg. Train Order Signal; Iron Pipe Post, Pipe Connected, with "Universal" Semaphore Casting.

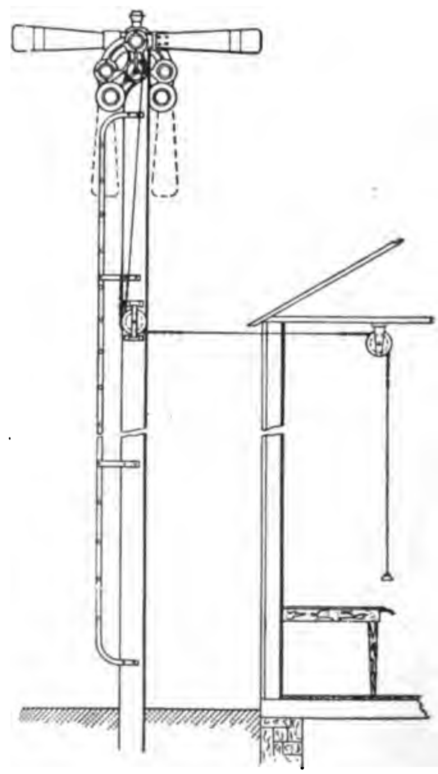
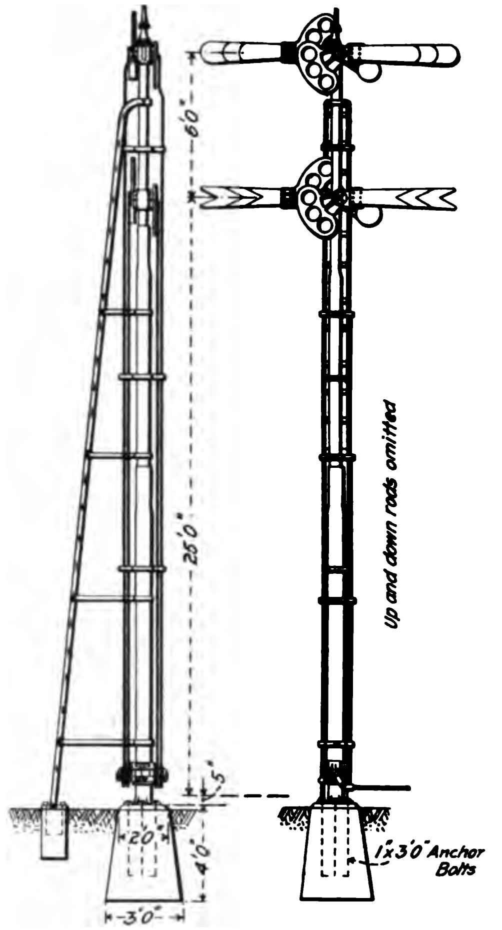


*Fig. 3086. Double, Two-Position, 90-Deg. Train Order Signal; Wooden Post, Wire Connected.



Figs. 3087-3088. Two-Arm, Double, Two-Position Train Order Signal; Iron Pipe Post, Pipe Connected. New York Central & Hudson River.

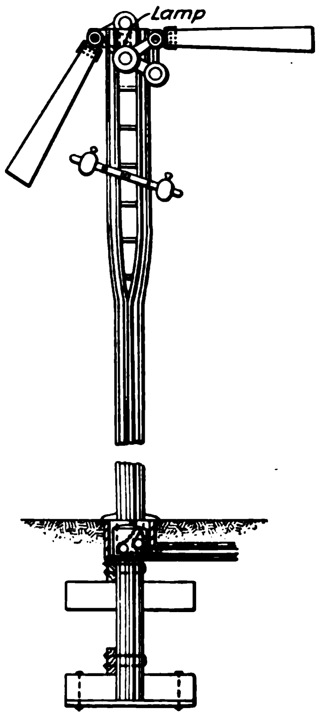


Fig. 3089. Double, Two-Position Train Order Signal; Post Made of Rails, Pipe Connected, Using Standard Semaphore Castings for Both Arms. Chicago & North-Western.

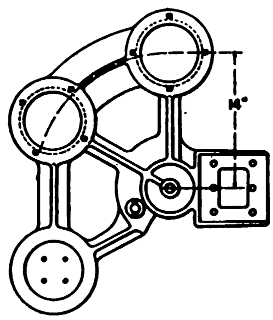


Fig. 3091.

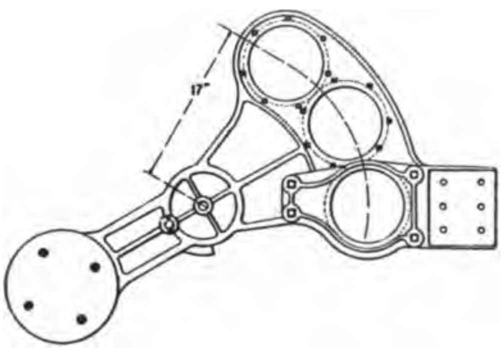


Fig. 3090.

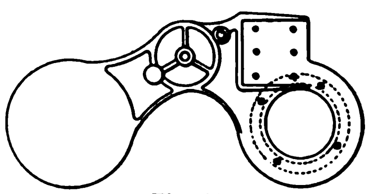


Fig. 3092.

*Figs. 3090-3092. Types of Train Order Semaphore Castings.

Fig. 3093. Train Order Semaphore Lantern. Adams & Westlake Company.

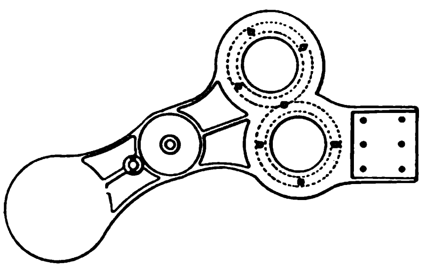
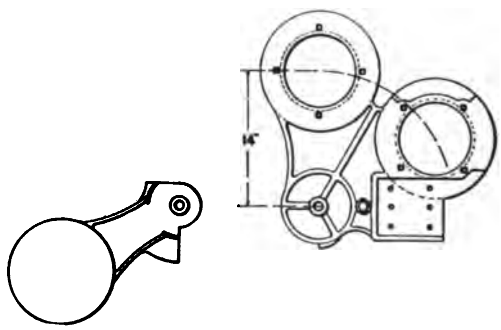
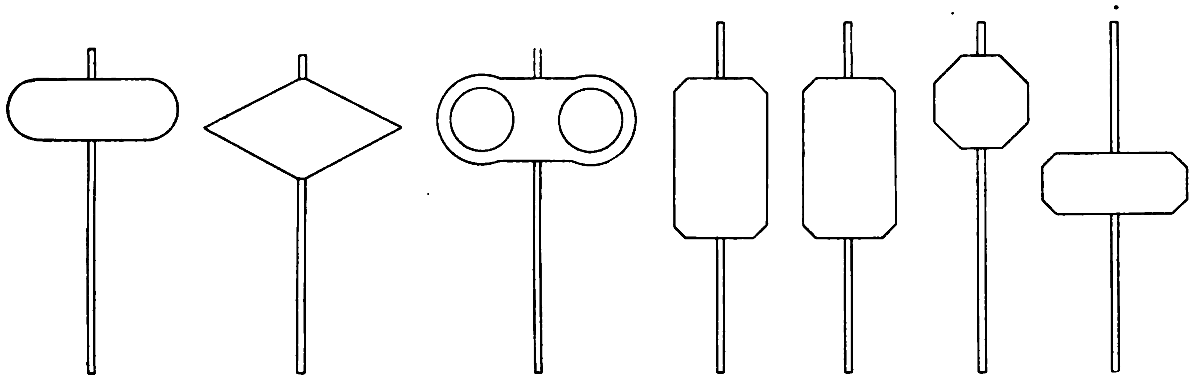


Fig. 3094. Semaphore Casting.

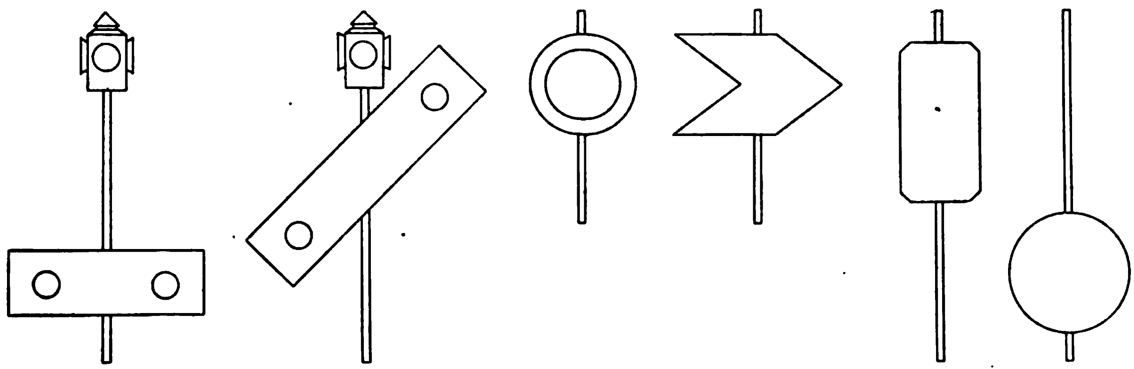


Figs. 3095-3096. Semaphore Casting with Detachable Counterweight.

*Figs. 3094-3096. Types of Train Order Semaphore Castings.

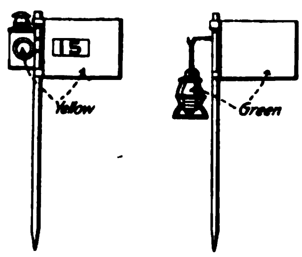


Figs. 3097-3103.



Figs. 3104-3109.

*Figs. 3097-3109. Types of Switch Targets.



Slow Sign. *Release Sign.*

*Figs. 3110-3111. Track Signs Suitable for a Road Using Green for Proceed and Yellow for Caution.

Fig. 3112. **Stop**—Swung Across the Track.

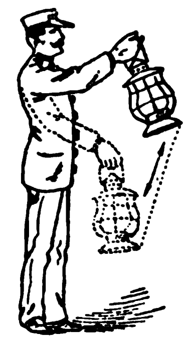


Fig. 3113. **Go Ahead**—Raised and lowered, the man facing toward the person to whom the signal is given.

Fig. 3114. **Back**—Swung vertically in a circle at half arm's length across the track.

Fig. 3115. **Train Has Parted**—Swung vertically in a circle at arm's length across the track.

Fig. 3116. **Apply Air-Brakes**—Swung horizontally in a circle.

Fig. 3117. **Release Air-Brakes**—Held at arm's length above the head.

Figs. 3112-3117. Hand Signals. To be given with Hand or Lantern.

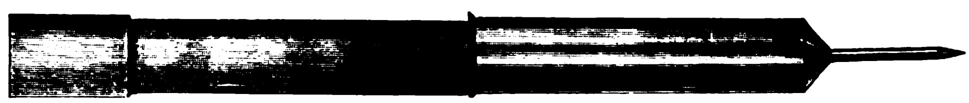


*Fig. 3118. Fusee.

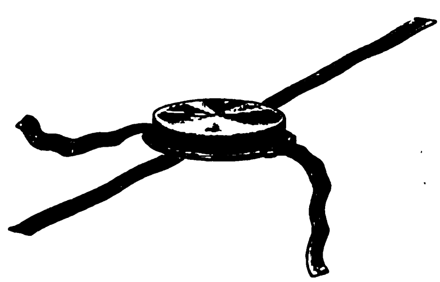


Fig. 3119.

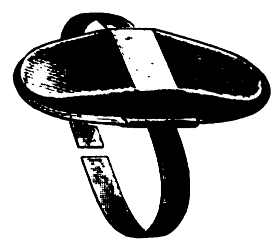


Fig. 3120.

*Figs. 3119-3120. Two Types of Torpedo.

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SEE PAGES 76, 399, 400 FOR DESCRIPTION OF SIGNAL AND RELAY.

See also pages 21 and 25.

See also pages 18-25.

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Automatic Railway Block Signals

Reliable Simple Durable

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**Operating parts few in number—
easy of access and readily removed.**

**Can be converted from downward to
upward moving in a few minutes.**

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Made in Porcelain, Steel-Enamel and Glass Jar Types

¶ This construction is our latest achievement in constant current batteries. Sizes range from 125 ampere hours to 1100 ampere hours capacity.

¶ Both electrodes are cylindrical. They are rigidly suspended from the cover, and interior short-circuiting by contact of the electrodes is impossible.

¶ Short-circuiting on the solution line of the electrolyte is positively prevented by the porcelain insulator, which is securely fastened between the positive electrode and the cover.

¶ Renewals can be made without touching the exhausted parts with the hands—an improvement not to be underestimated by one experienced in the handling of caustic alkaline batteries. Three thumb screws on the top of the cover control the entire renewal operation.

¶ There are but two parts to the renewal—a positive and a negative element.

¶ Steel-enameled jars are fitted with solution tight covers for marine work.

¶ We make to order cylindrical electrodes to fit any of the standard makes of battery jar covers.

¶ *OUR GUARANTEE.—Non-freezing—no interior short-circuiting—a higher E. M. F. and greater output than any other cell of similar type and size.*

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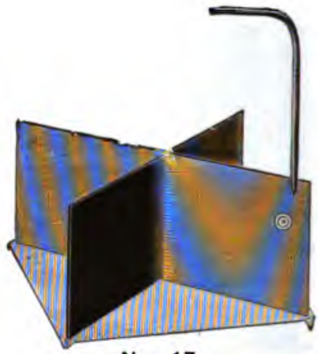
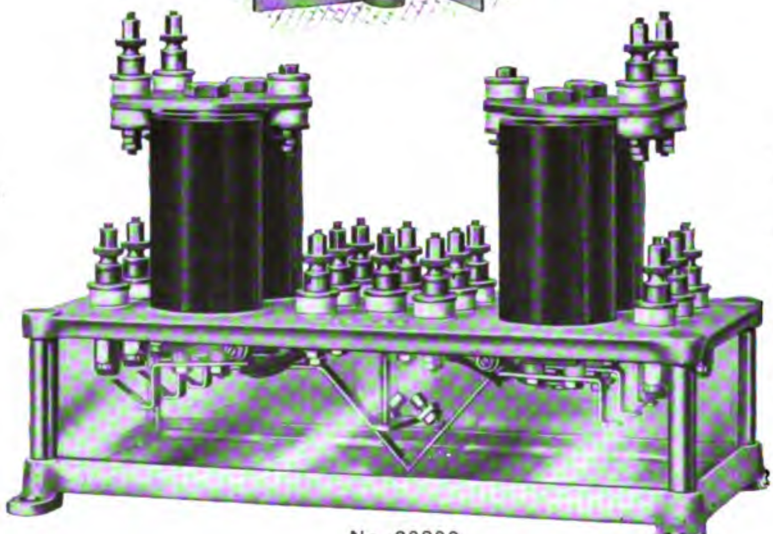
STANDARD AMALGAM

No. 16
3-LEAF COPPER



No. 17
COPPER (PAN BOTTOM)

RELAYS
ANNUNCIATORS
INDICATORS
STORAGE &
PRIMARY
BATTERIES



BOND-WIRES
CHANNEL-PINS
ZINCS
COPPERS
CROSSING
ALARMS

No. 20290
INTERLOCKING RELAY

BRYANT ZINC COMPANY

CHICAGO — Manufacturers RAILWAY SUPPLIES — NEW YORK